Revised HST Modeling Study
Model Development and Calibration

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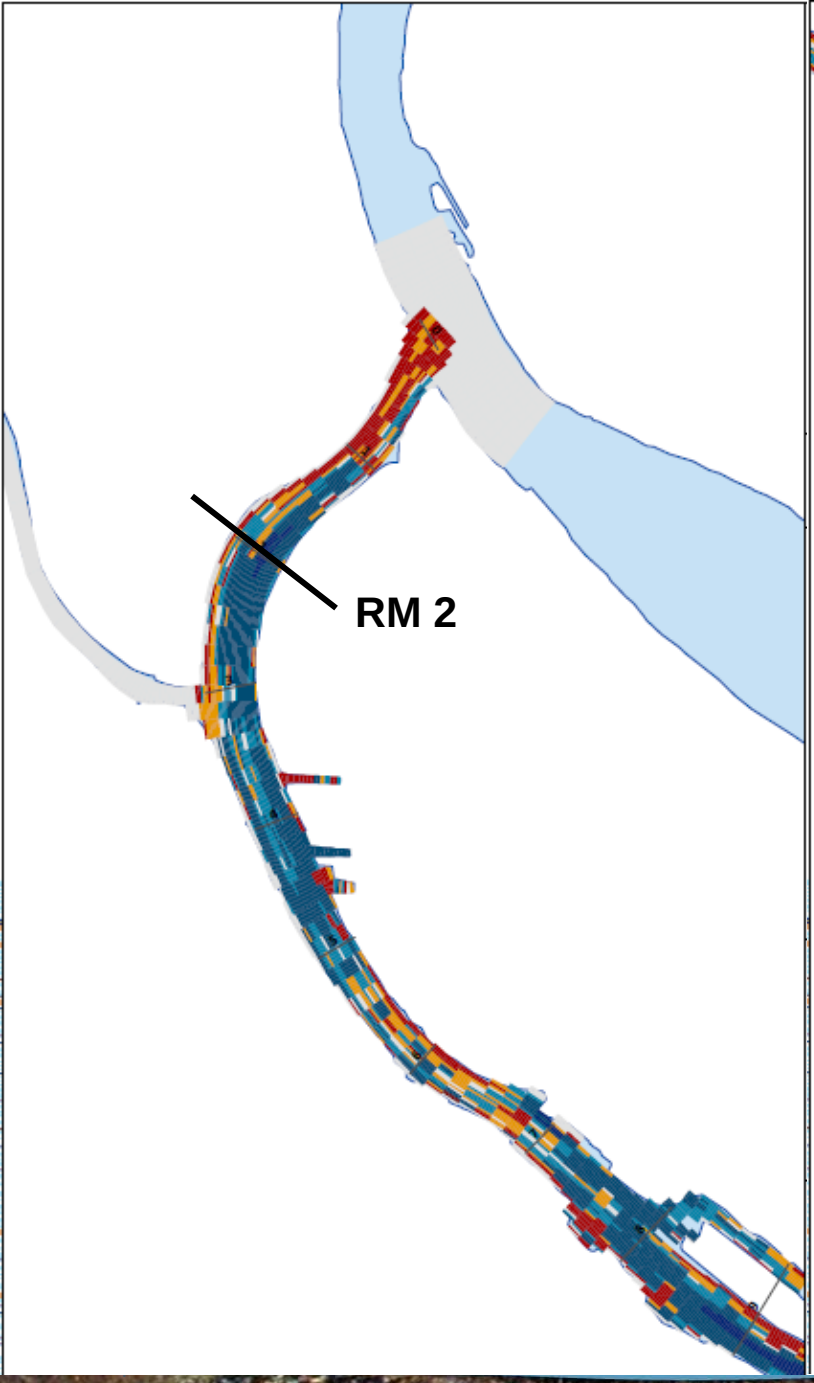
Presentation Overview

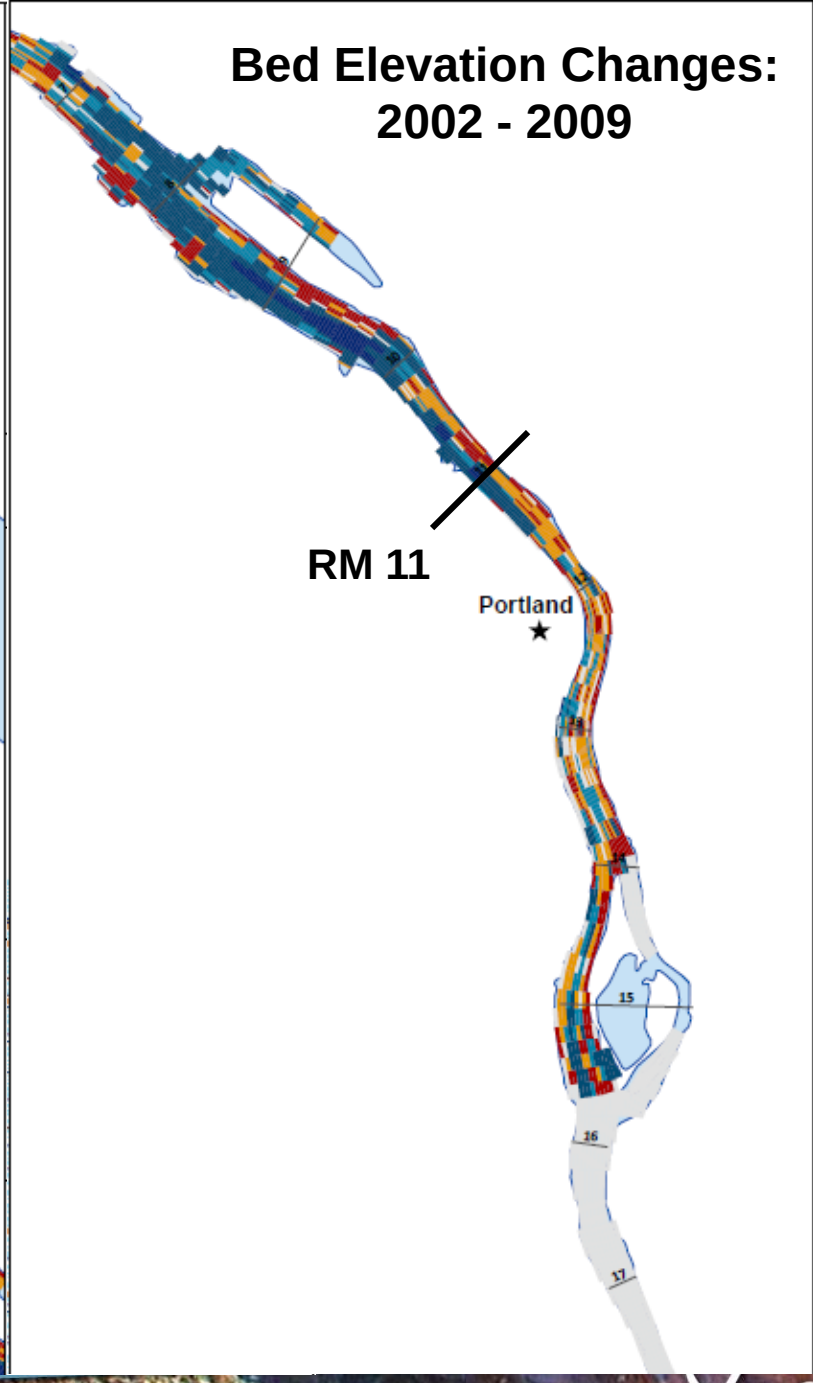
- Analysis of DEA bathymetric data (2002-09 period)
- Sediment transport model development
- Review of model calibration results

DEA Bathymetry Analysis

- DEA analyzed changes in bed elevation during the 7-year period from January 2002 to January 2009
- Study Area is RM 1.9-11.8
  - Today's presentation focuses on RM 2-11
  - Not expected to impact calibration
- Insights about sediment transport processes gained from analysis of bed elev. changes during:
  - 7-yr period – 2002 to 2009
  - 16-month period – Jan 2002 to May 2003
  - 10-month period – May 2003 to Mar 2004
  - 58-month period – Mar 2004 to Jan 2009

Bed Elevation Changes: 2002 - 2009





2009 minus 2002

LEGEND

- ★ Population Centers
- Shoreline

Bathymetry Change (cm)

- < -100
- -100 to -10
- -10 to -1
- -1 to 1
- 1 to 10
- 10 to 100
- > 100

NOTES:

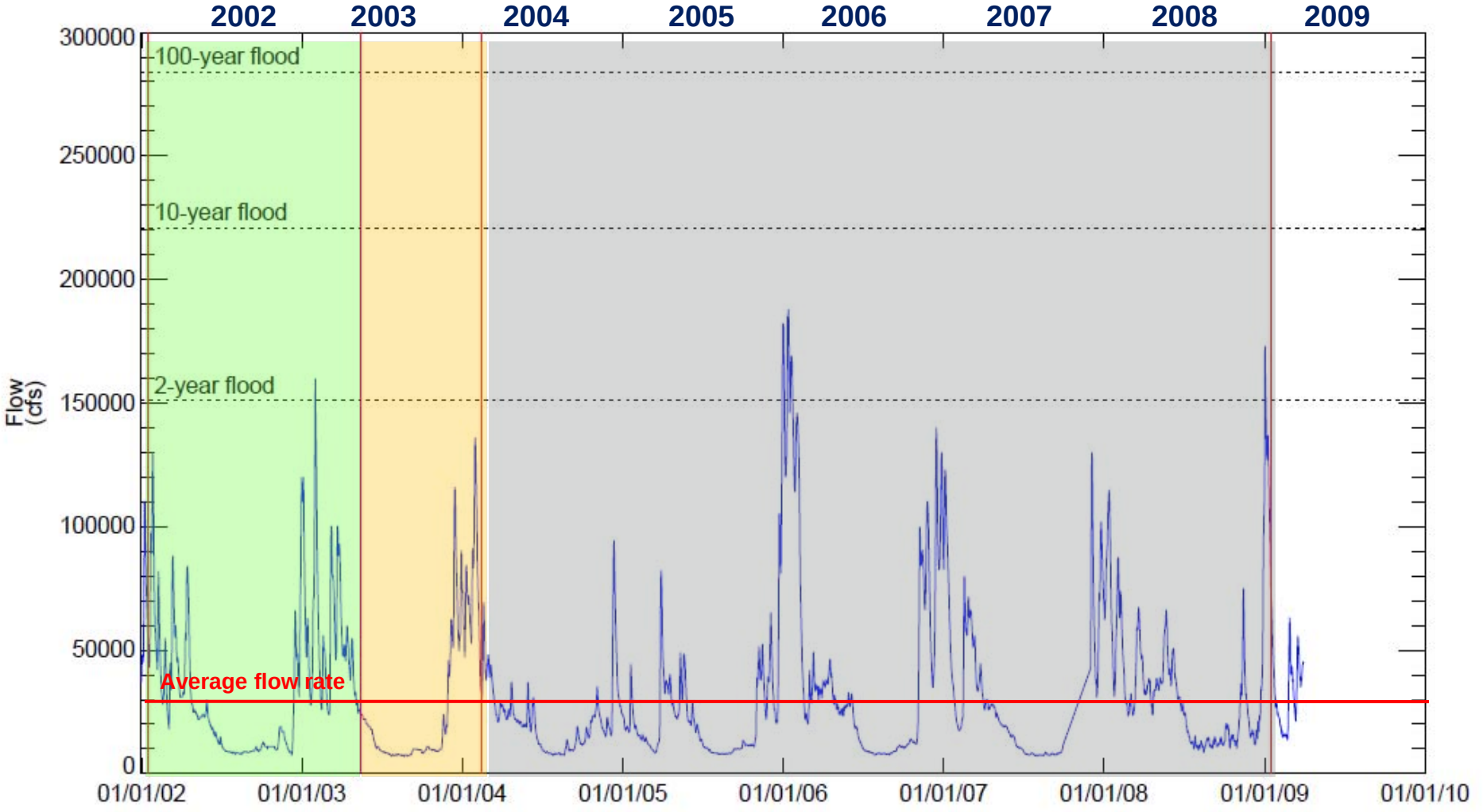
Based on bathymetry difference rasters from the client. Client's rasters were calculated as 2002 minus 2009; the rasters were multiplied by -30.48 to convert to 2009 minus 2002, and from ft to cm.

Miles

0 0.5 1

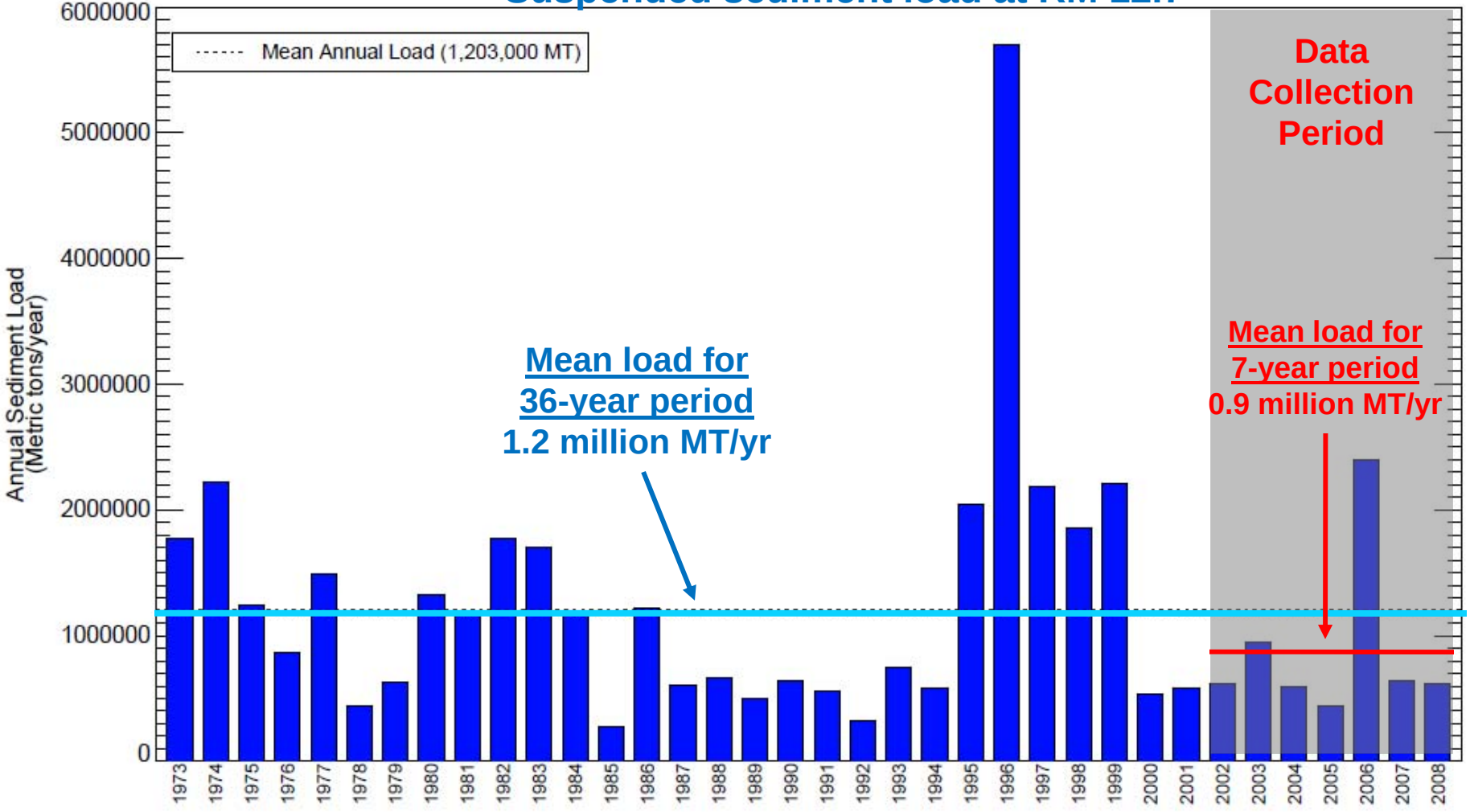
QEA

LWR Hydrograph: 2002 – 2009

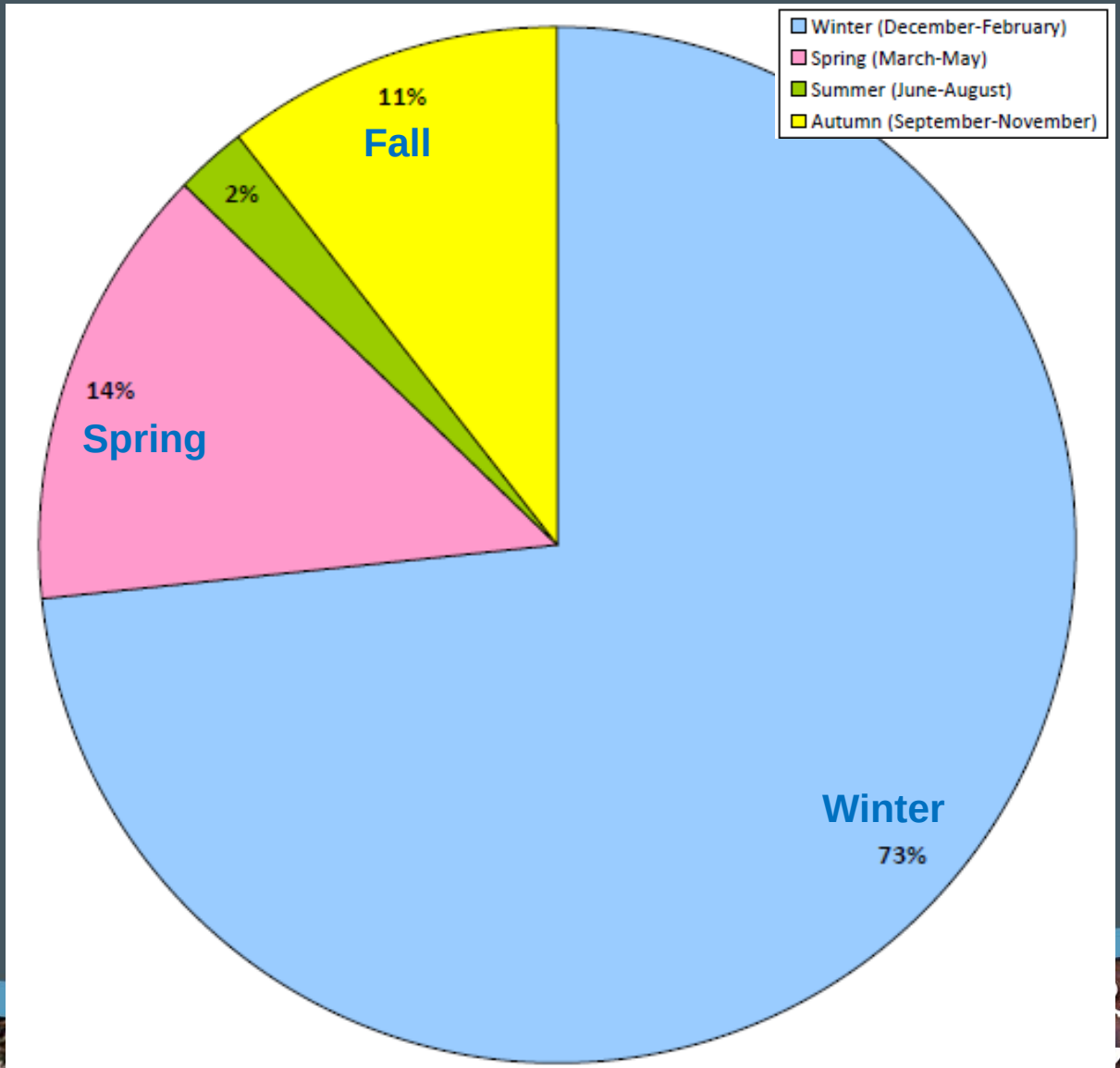


Upstream Sediment Load: Annual Variability

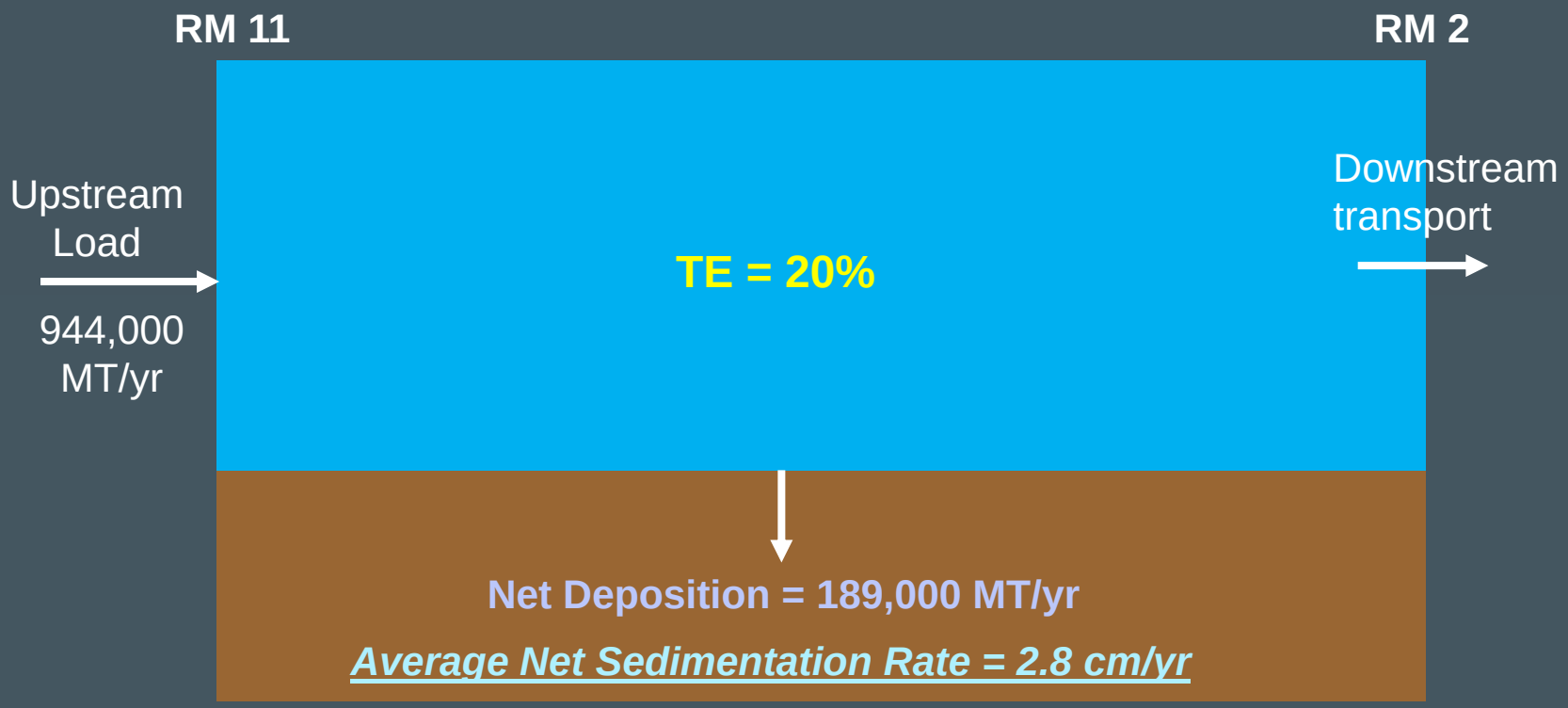
Suspended sediment load at RM 12.7



Upstream Sediment Load Analysis:
Seasonal Variability

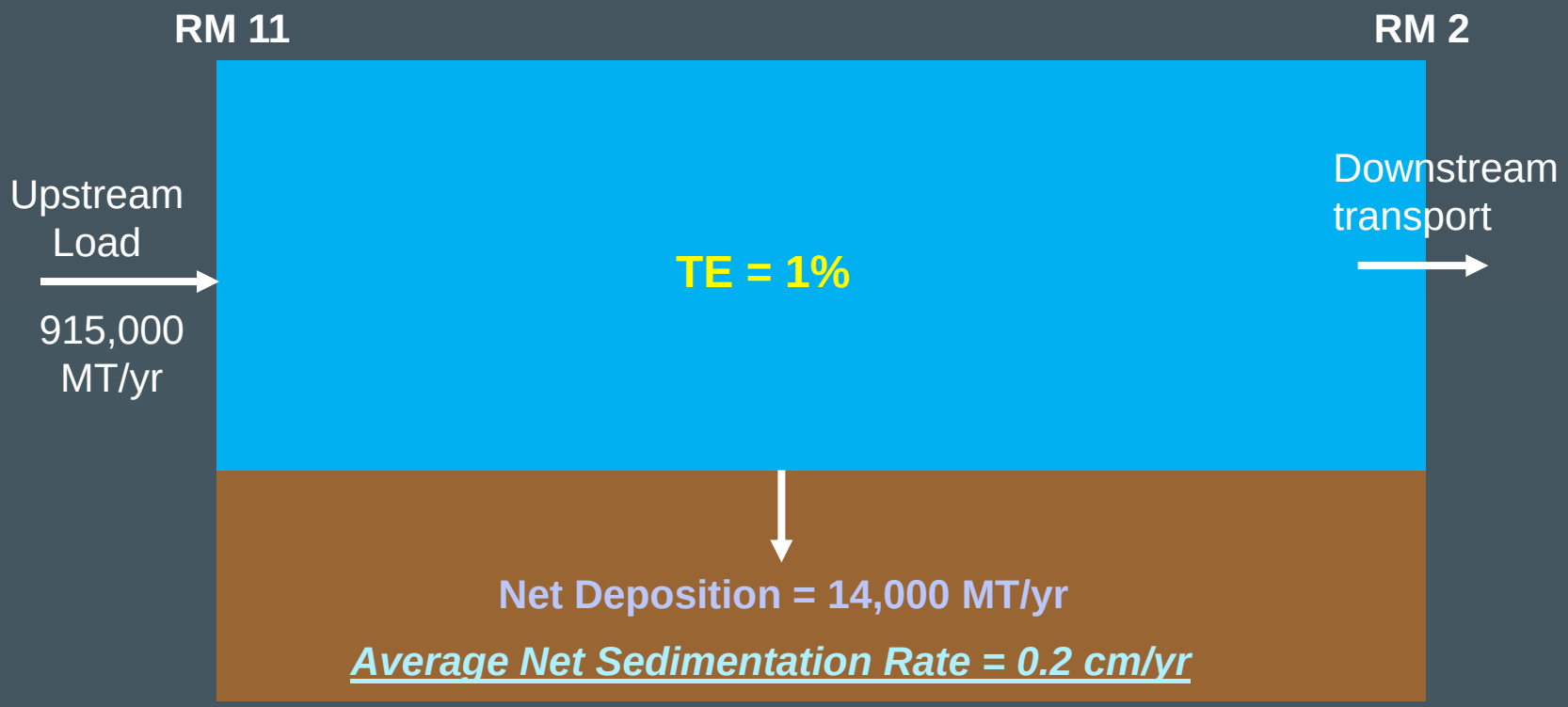


Data-Based Mass Balance: 2002-2009



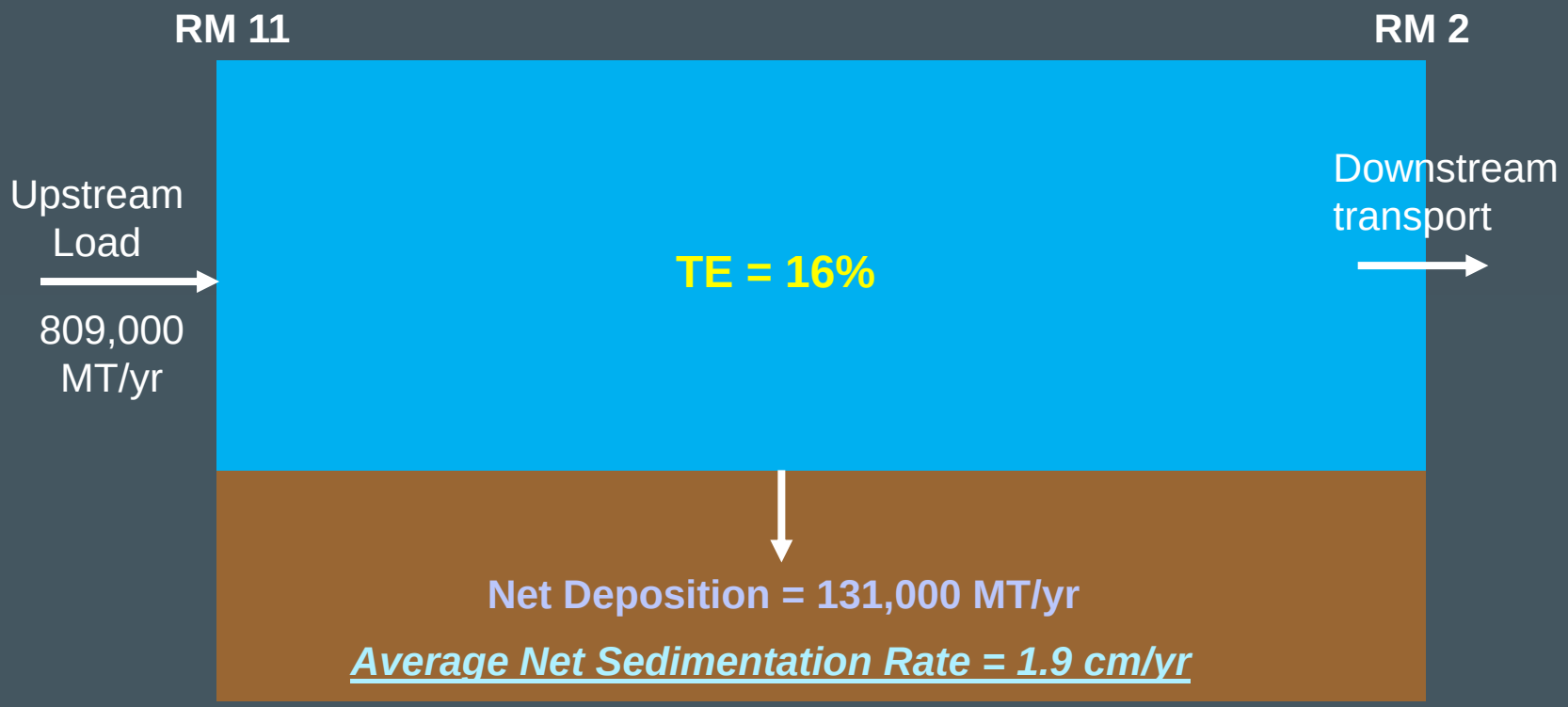
Trapping Efficiency (TE): portion of incoming load deposited in LWR

Data-Based Mass Balance: January 2002 – May 2003



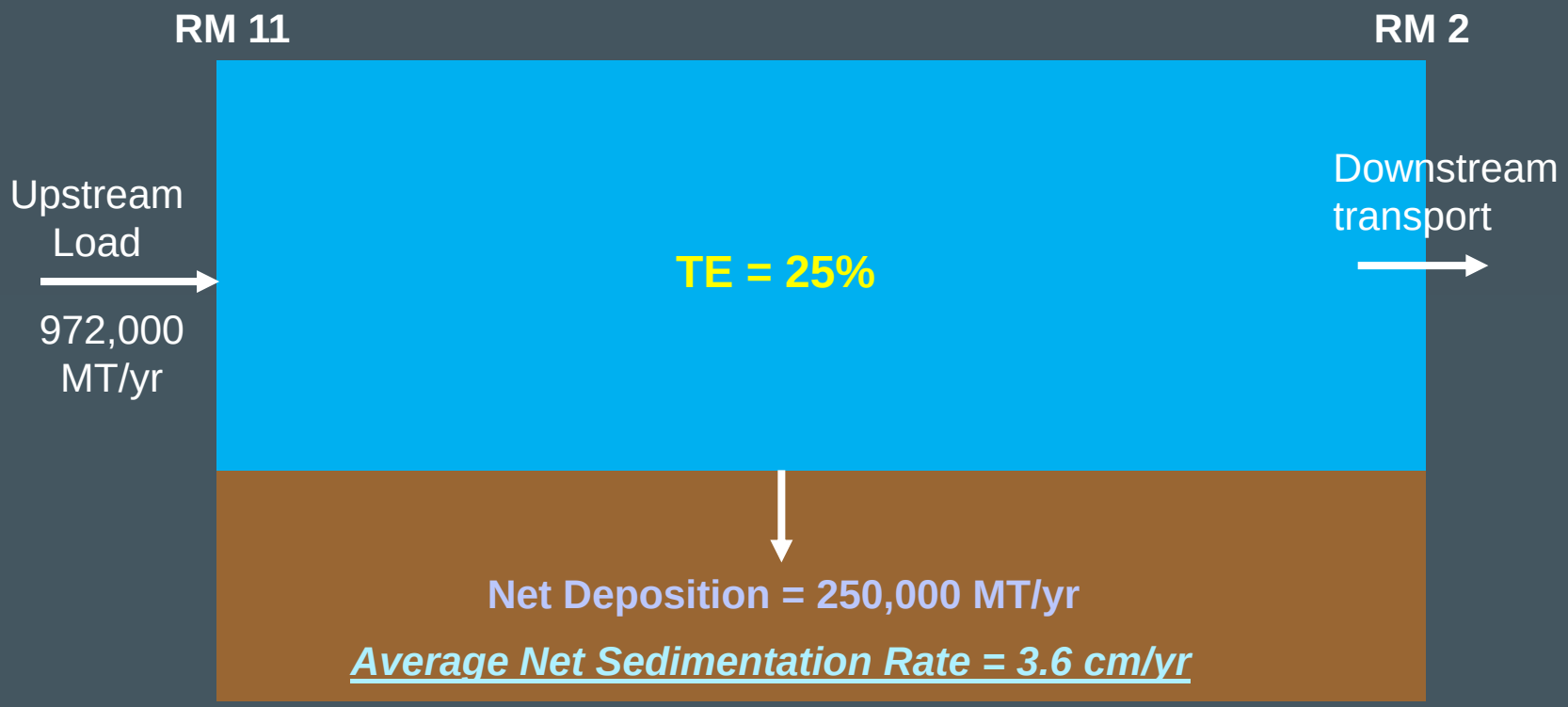
Trapping Efficiency (TE): portion of incoming load deposited in LWR

Data-Based Mass Balance: May 2003 – February 2004



Trapping Efficiency (TE): portion of incoming load deposited in LWR

Data-Based Mass Balance: February 2004 – January 2009



Trapping Efficiency (TE): portion of incoming load deposited in LWR

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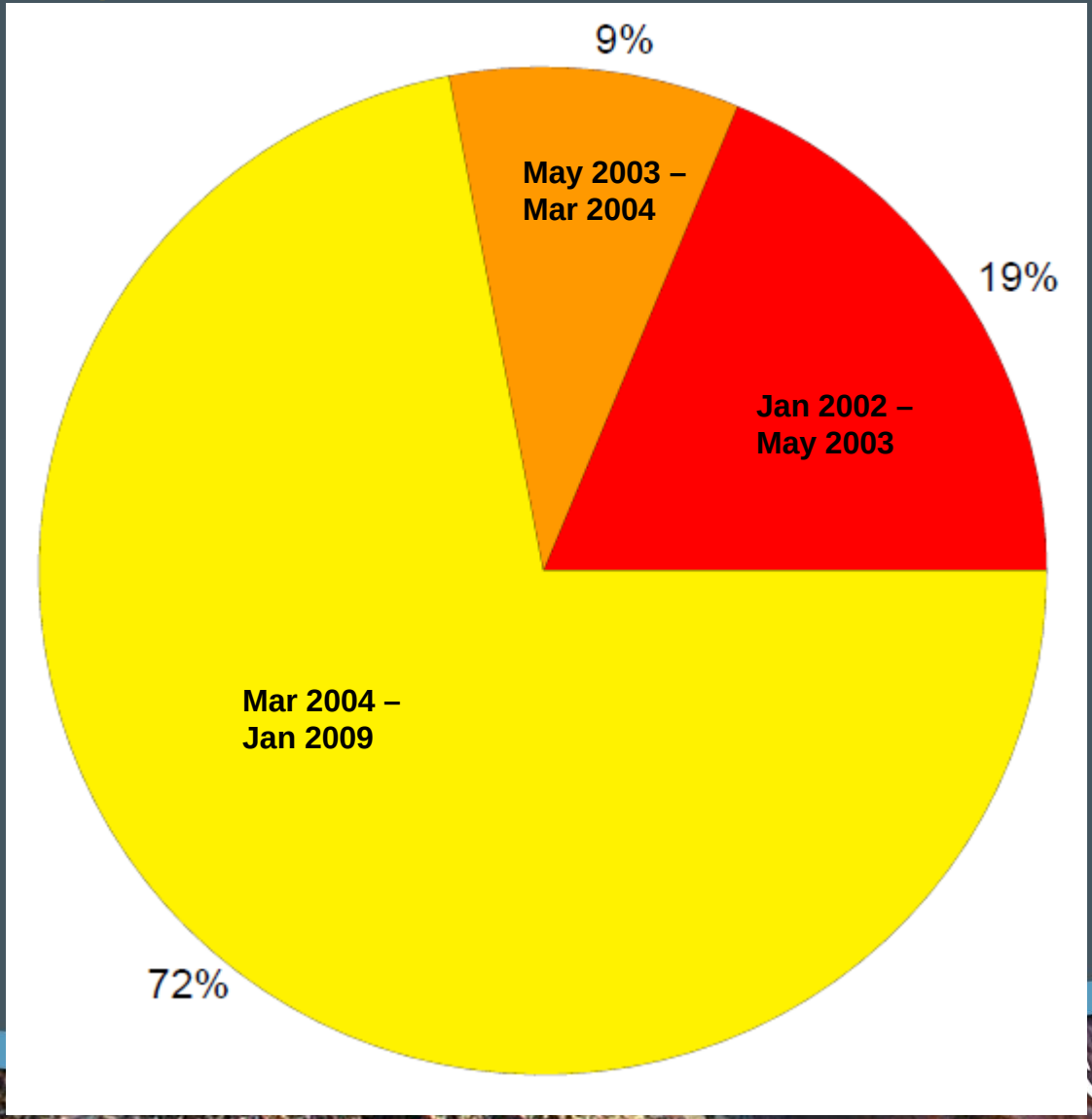
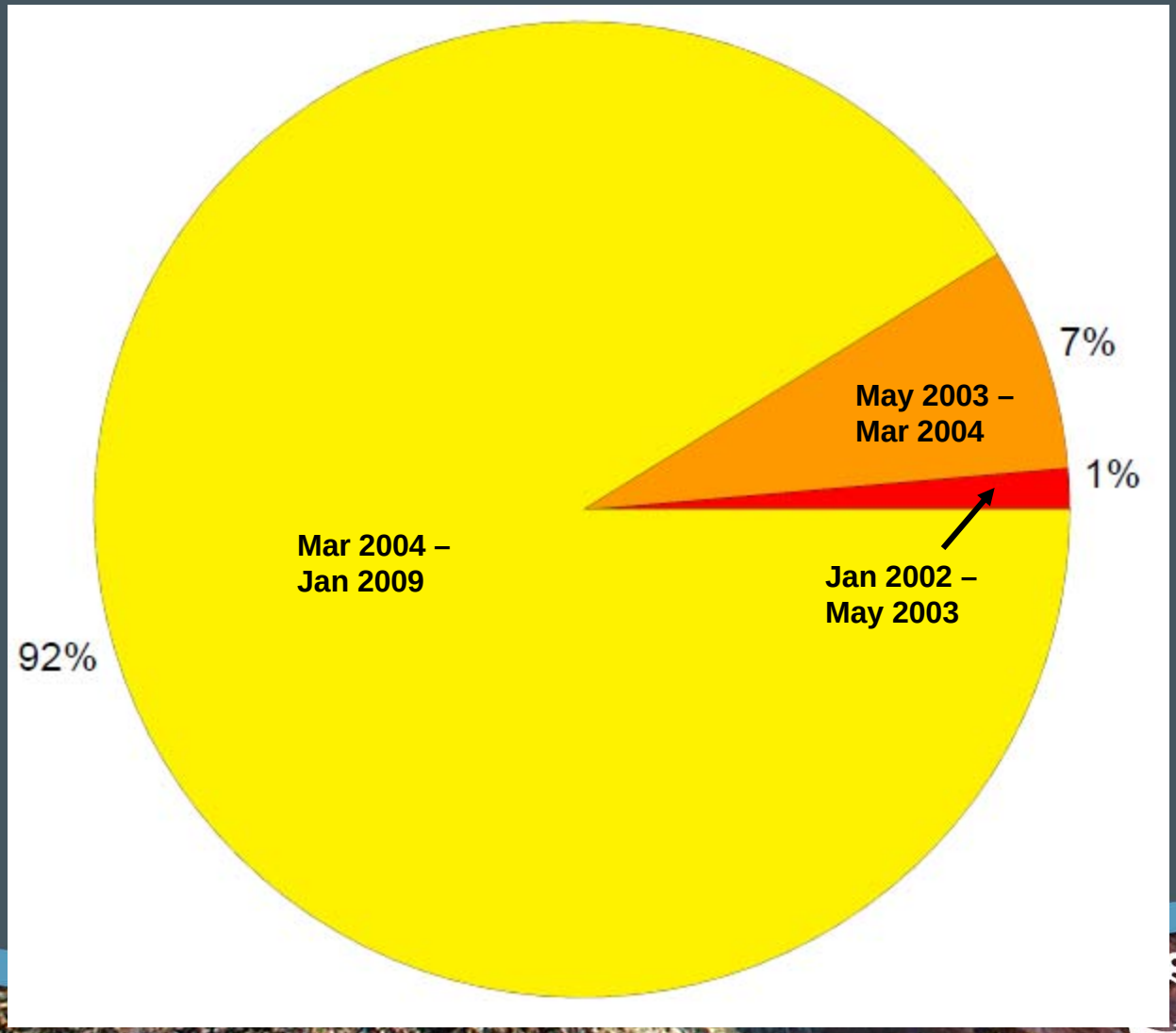
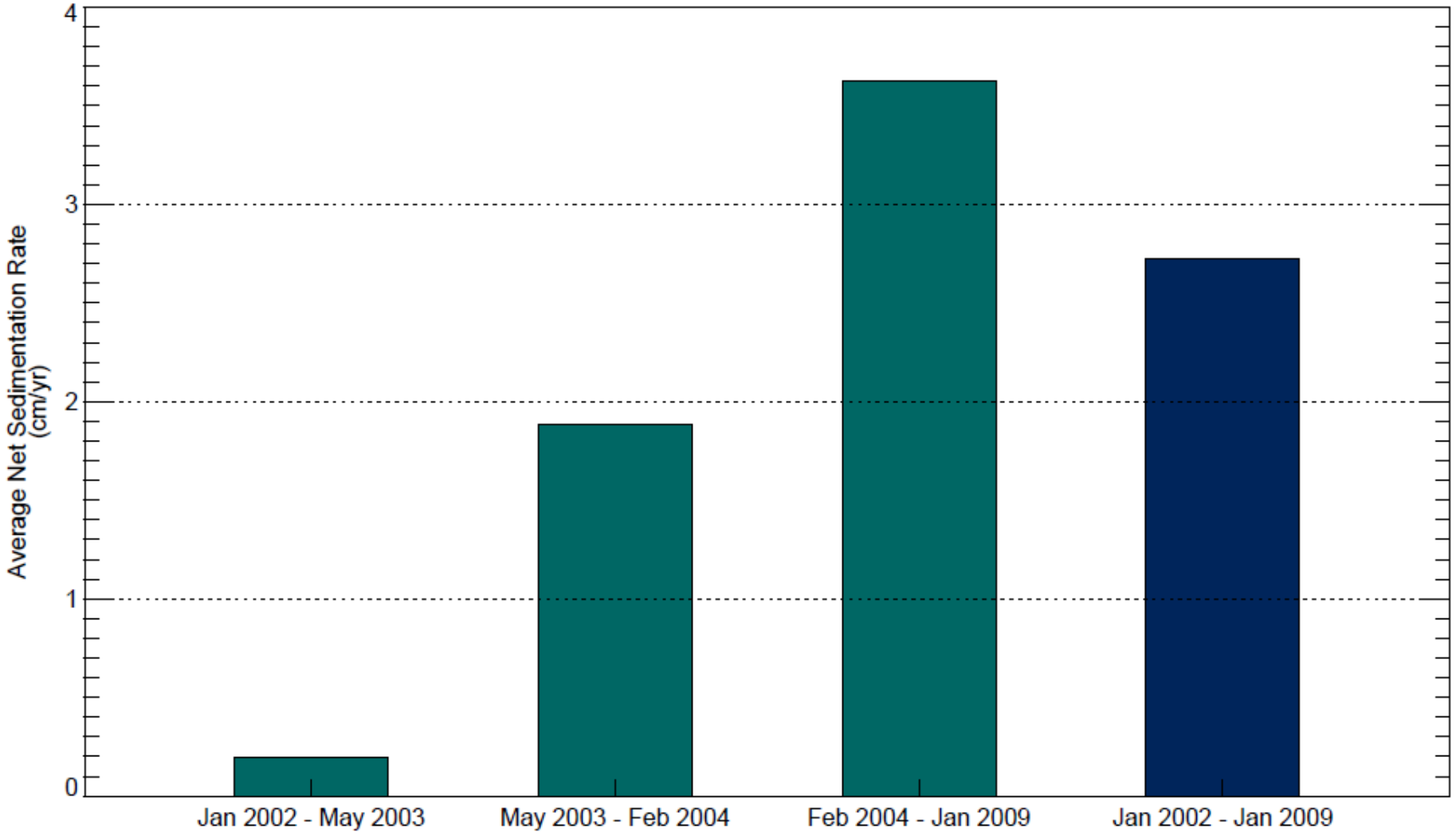
2002-09 Temporal Distribution: Incoming Sediment Load



2002-09 Temporal Distribution:
Net Deposition Within RM 2-11



2002-09 Temporal Distribution:
Net Sedimentation Rate Within RM 2-11



Implications for HST Model Calibration

- Jan 2002 to May 2003 period is significantly different with respect to net sedimentation, even though the incoming sediment load is similar to the May 2003 to January 2009 period

- Use of data from Jan 2002 to May 2003 period for calibration would have produced a model that predicted relatively low rates of natural recovery
  - This period appears to be anomalous

Implications for HST Model Calibration

- Use of data from May 2003 to Jan 2009 period for calibration will produce a robust model that is more representative of long-term sediment transport processes in the study area (RM 2-11)

Modifications to Hydrodynamic Model

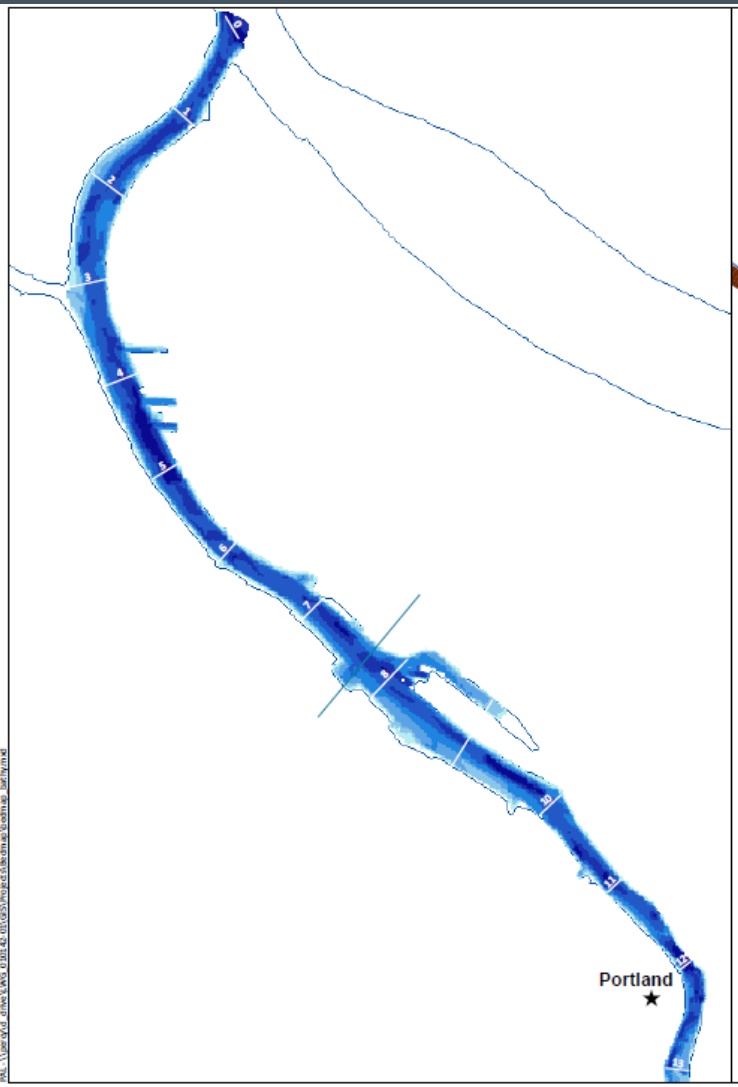
- Additional evaluation of the hydrodynamic model revealed two problems that required modification of the model inputs
  - Upstream inflow BC in Columbia River
  - Spatial distribution of effective bed roughness

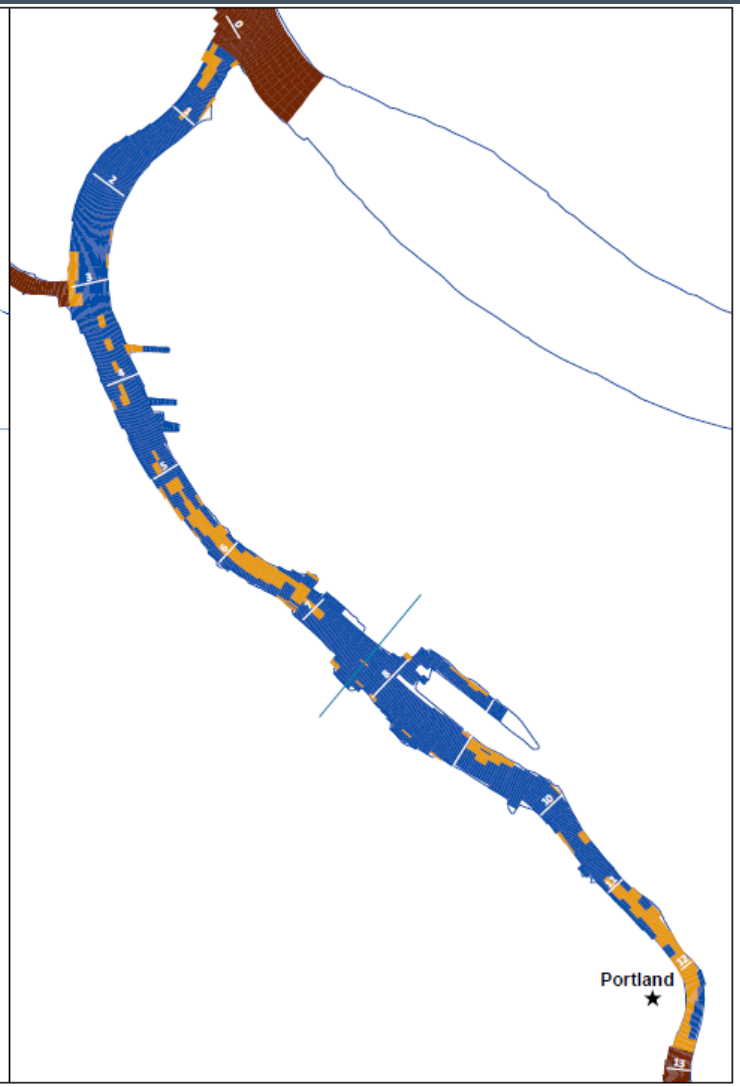
- These two issues were resolved, which resulted in improved model performance

Specification of HST Model Inputs

- The following HST model inputs were specified using site-specific data:
  - Erosion rates of cohesive sediment
  - Bulk properties of non-cohesive sediment
  - Incoming sediment load (magnitude and composition)
  - Spatial distributions of effective bed roughness (D_{90}) and bed composition
  - Bulk (dry) density

Bathymetry and Bed Map





LEGEND

Match Lines

River Miles (white lines and numbers)

Shoreline

LEFT PANEL

Feb 2004 Bathymetry (NAVD88 ft)

- -90.6 - -55.6
- -55.5 - -44.3
- -44.2 - -35.8
- -35.7 - -26.9
- -26.8 - -17.1
- -17.0 - -6.0
- -5.9 - 10.1

RIGHT PANEL

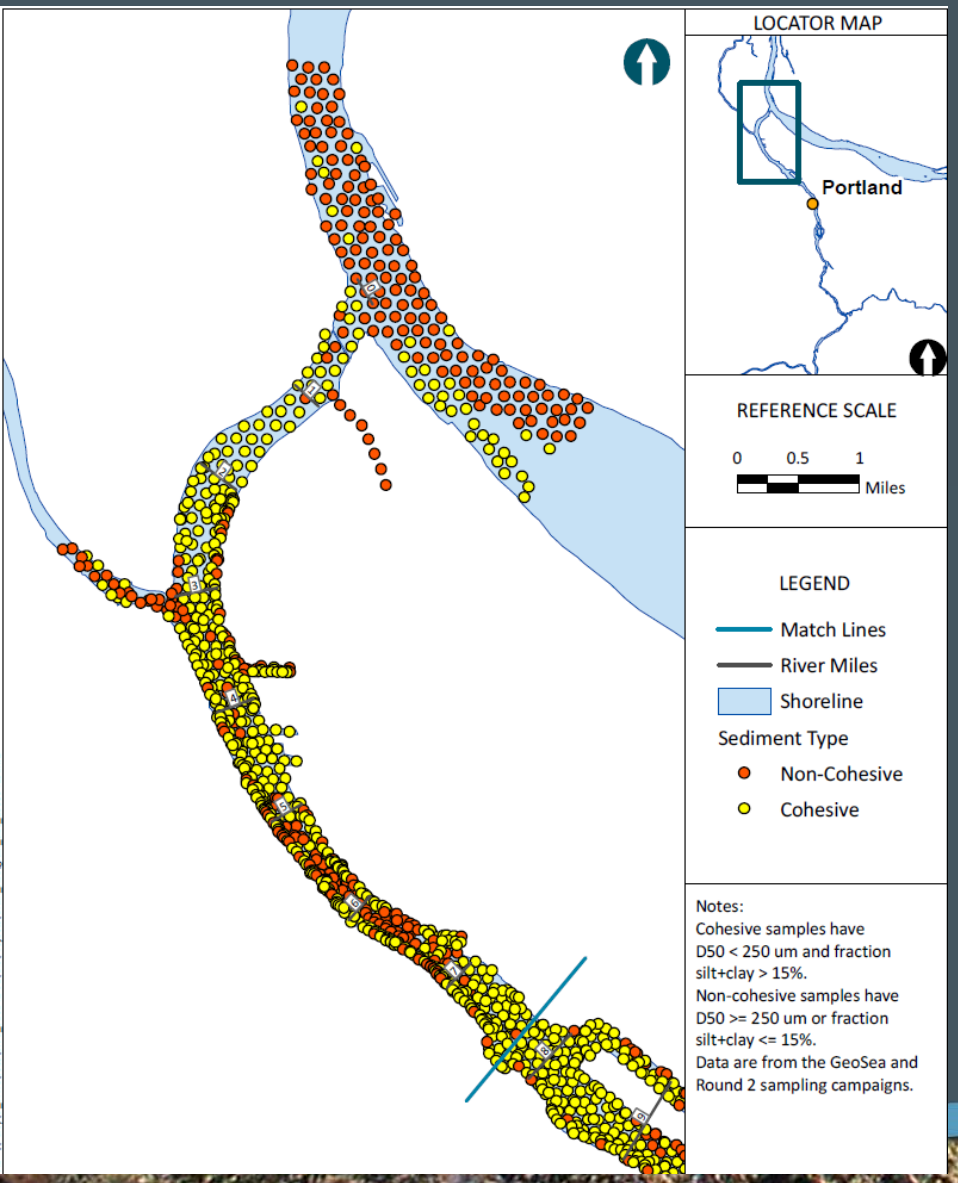
Model Grid Bedmap

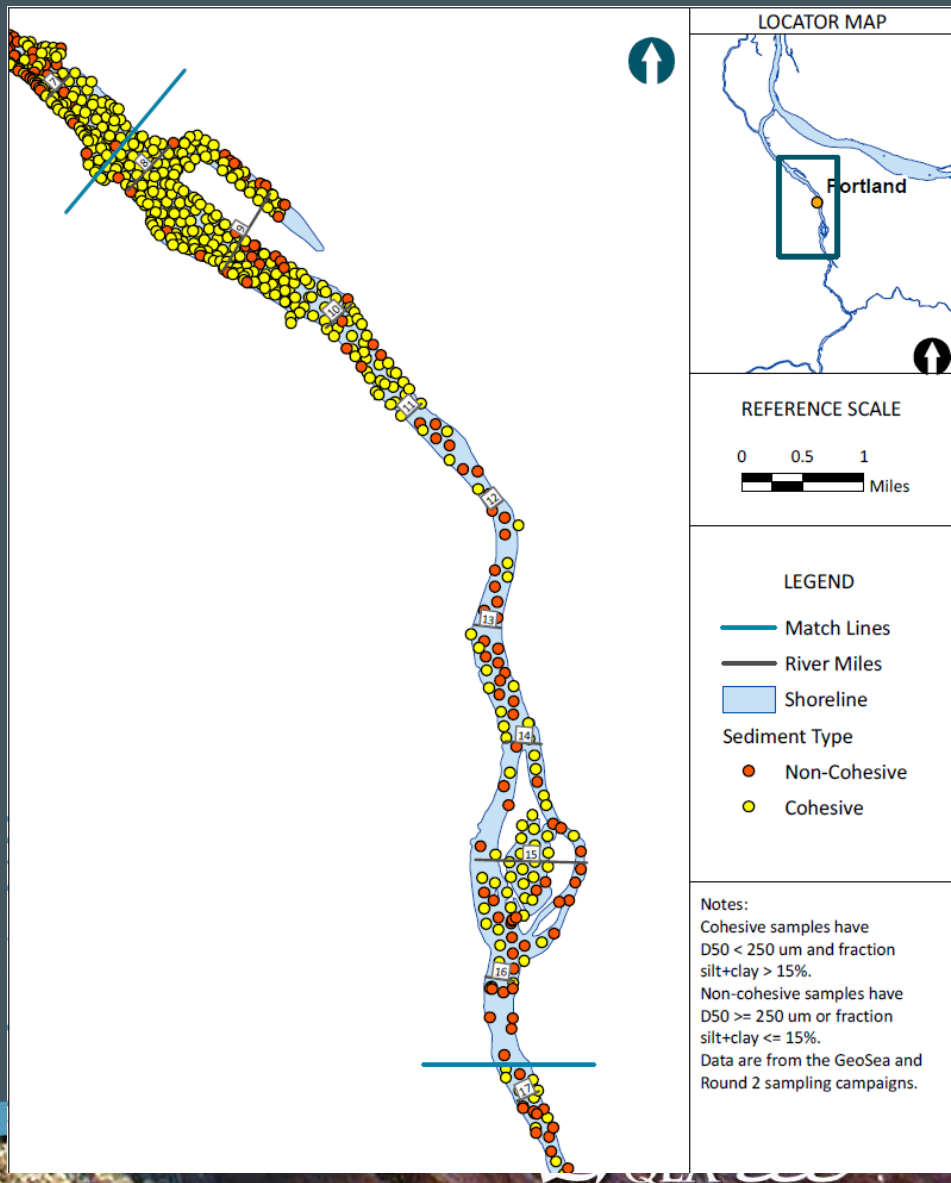
- Hard-Bottom
- Cohesive
- Non-Cohesive

NOTES:
Bathymetry data from West.
Bedmap based on data from GeoSea and Round 2 sampling campaigns.

Miles
0 1 2

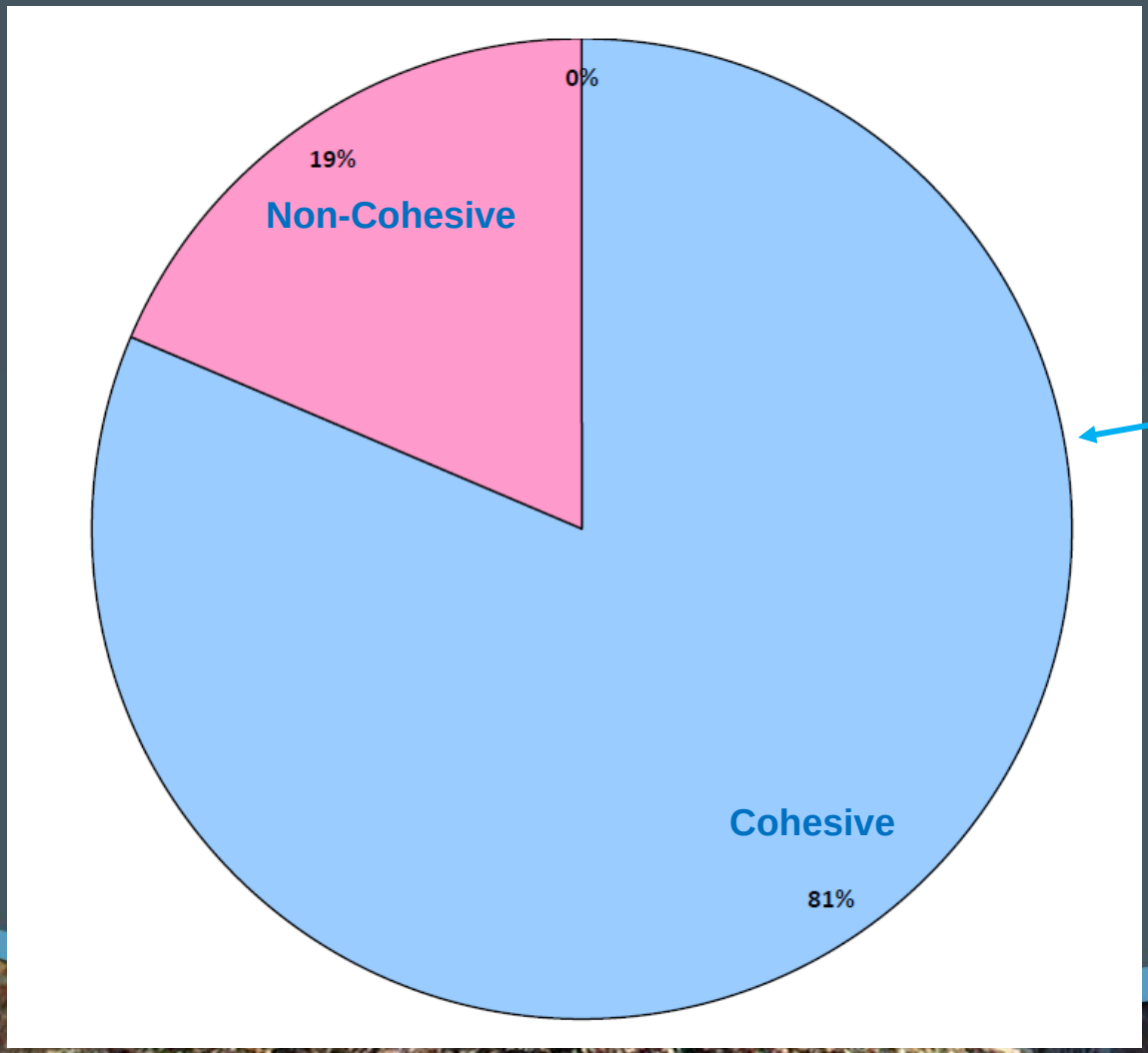
Bed Type Mapping





Bed Type Mapping: RM 2 to 11

Surface sediment: 411 GeoSea cores



Sedflume core data are used to specify erosion properties in cohesive bed areas

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Analysis of Erosion Rate (Sedflume) Data

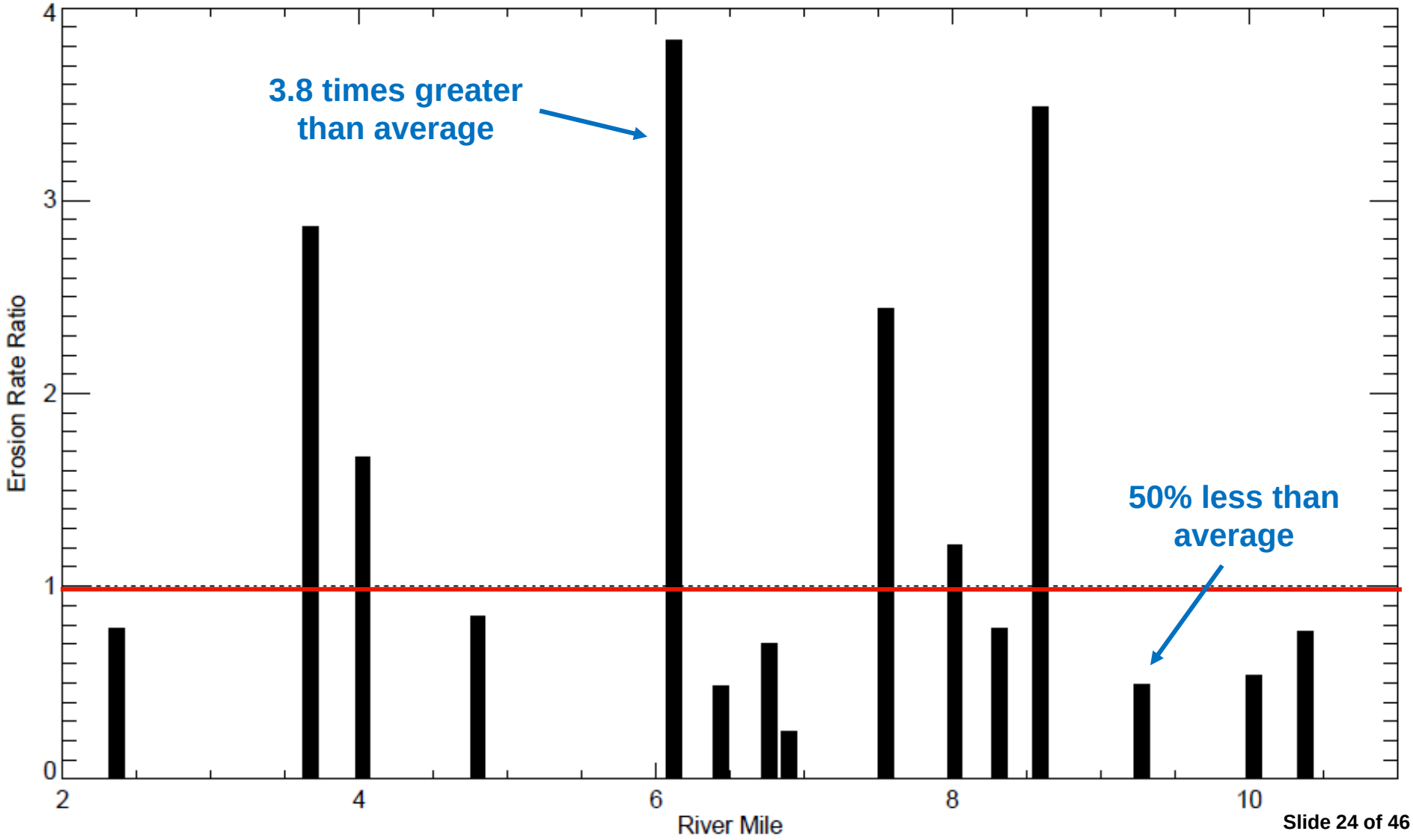
- Sedflume core data collected during 2006 were analyzed
  - Focus was on horizontal and vertical variability
- LWR data were compared to Sedflume data from two other sites
  - Lower Duwamish Waterway
  - Estuary on Gulf Coast

Analysis of Erosion Rate (Sedflume) Data

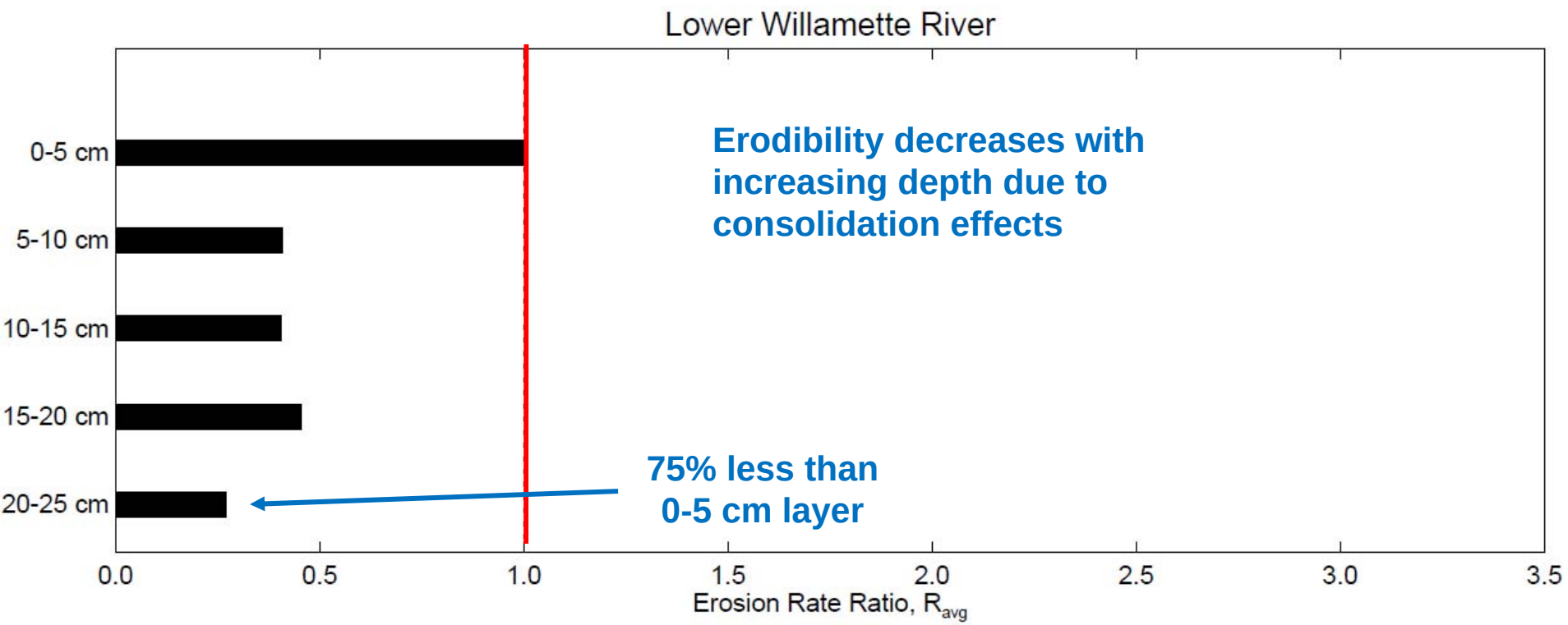
- Inter- and intra-site comparisons of erosion rate data are possible using the erosion rate (ER) ratio

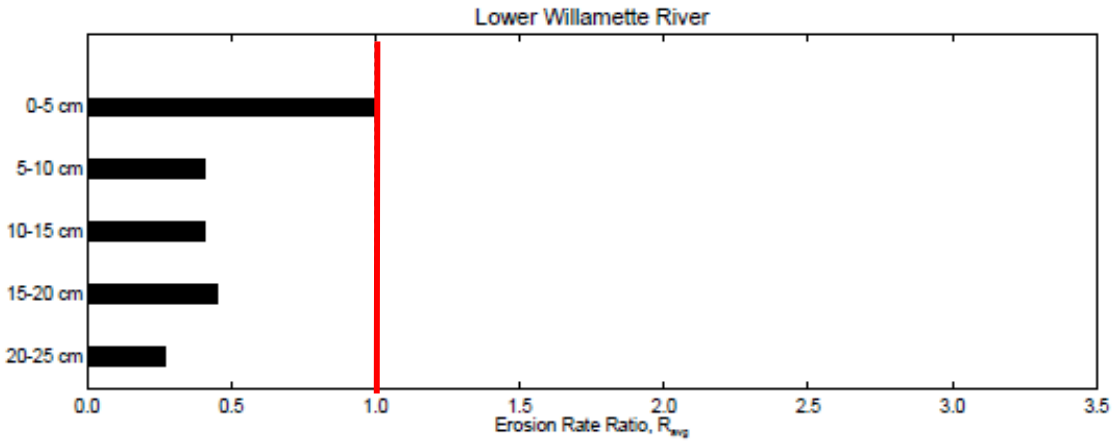
- ER ratio compares erodibility of a core to the average erodibility of all cores at a site
  - ER ratio < 1 → erodibility is less than average
  - ER ratio > 1 → erodibility is greater than average

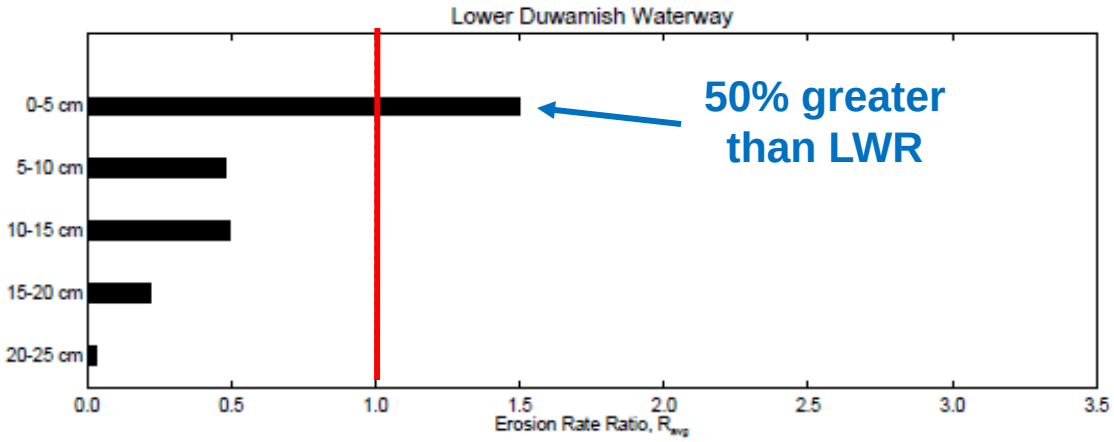
Spatial Variability of LWR Erodibility:
0 – 5 cm Layer

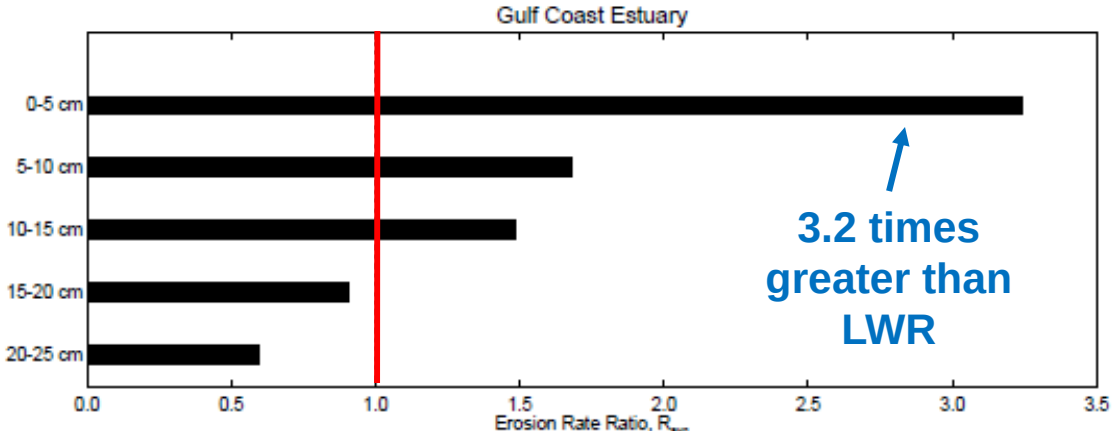


Vertical Variability of LWR Erodibility









HST Model Calibration: General Strategy

- Primary calibration target is bed elevation change in the study area (RM 2-11) during ~5.5-year period (May 2003 to January 2009)

- Evaluate model performance over wide range of spatial scales
  - Large-scale: entire study area (~1,800 acres)
  - Small-scale: grid cell (~1 acre)

HST Model Calibration: Data Density Within Study Area (RM 2-11)

- Density of bed elevation change data used for evaluating model performance is high
  - Typical HST model: 2 – 10 data points
  - LDW HST model: 58 data points
  - LWR HST model: ~1,600 data points
- Each LWR data point represents bed elevation change within 1 grid cell
  - Average area: 1.1 acres
  - Range: 0.6 – 1.9 acres
- The large number of LW data points used for evaluating HST model performance is unique

HST Model Calibration:
Calibration Parameters

- Four input parameters were adjusted, within realistic ranges, during the calibration process:
  - Effective diameters of sediment size classes 1, 2 and 3
  - Active layer thickness of non-cohesive sediment

HST Model Calibration:
Effective Diameters of Classes 1, 2 and 3

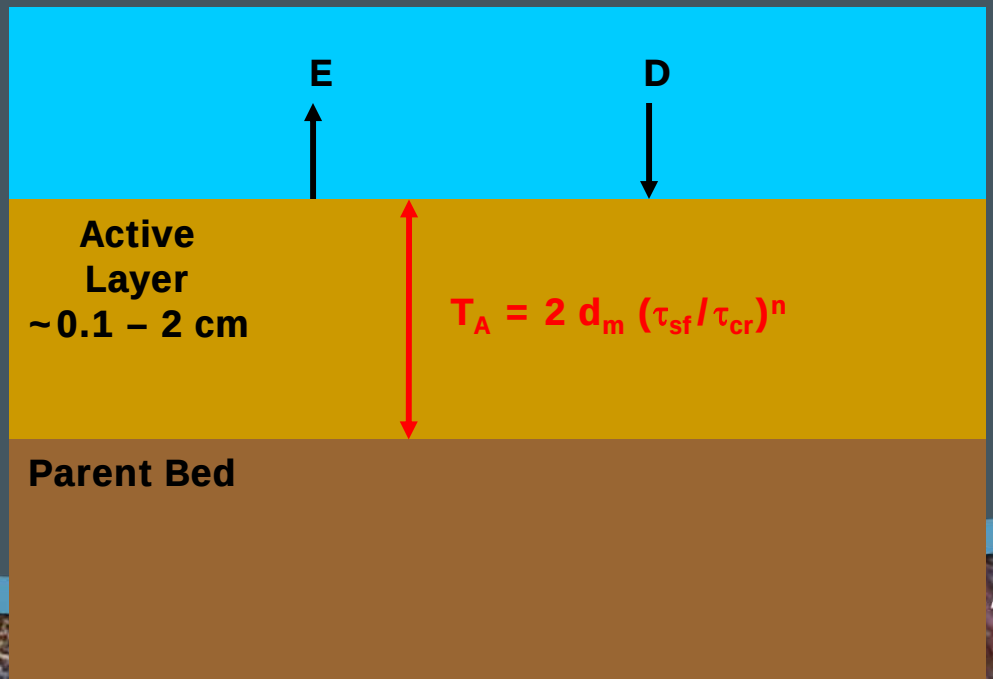
- Four sediment size classes are used in the model
- Effective diameters of classes 1, 2 and 3 were adjusted
  - Affects deposition and erosion processes

Sediment Class	Particle Size Range (μm)	Effective Diameter (μm)
1: clay/silt	<62	15
2: fine sand	62 – 250	90
3: medium & coarse sand	250 – 2,000	700
4: gravel	>2,000	2,750

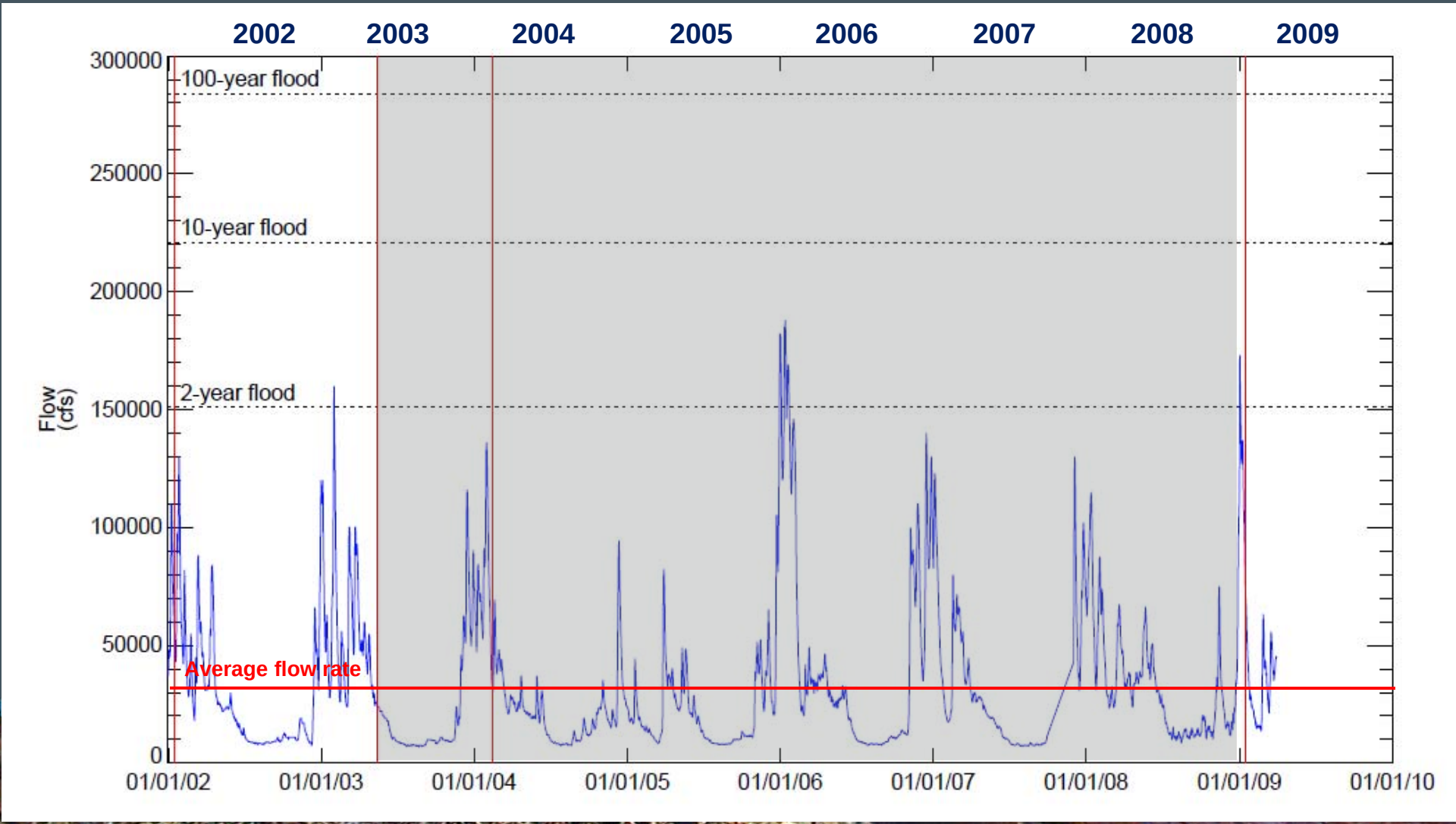
HST Model Calibration:

Active Layer Thickness, Non-Cohesive Bed

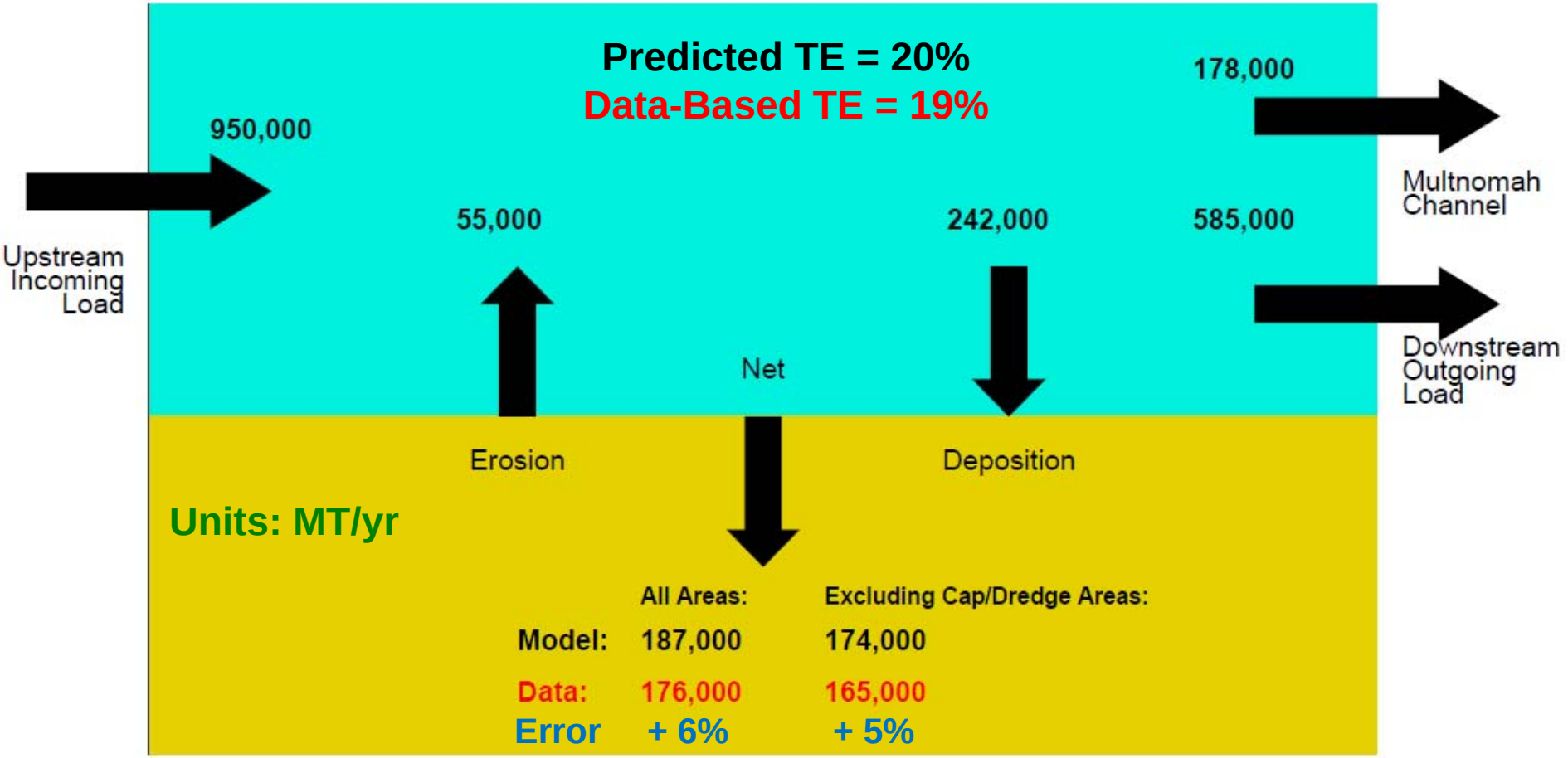
- Active layer thickness affects erosion of non-cohesive bed
- Shear stress exponent (n) was adjusted
  - Range: 0.1 – 1
  - Set n = 0.5



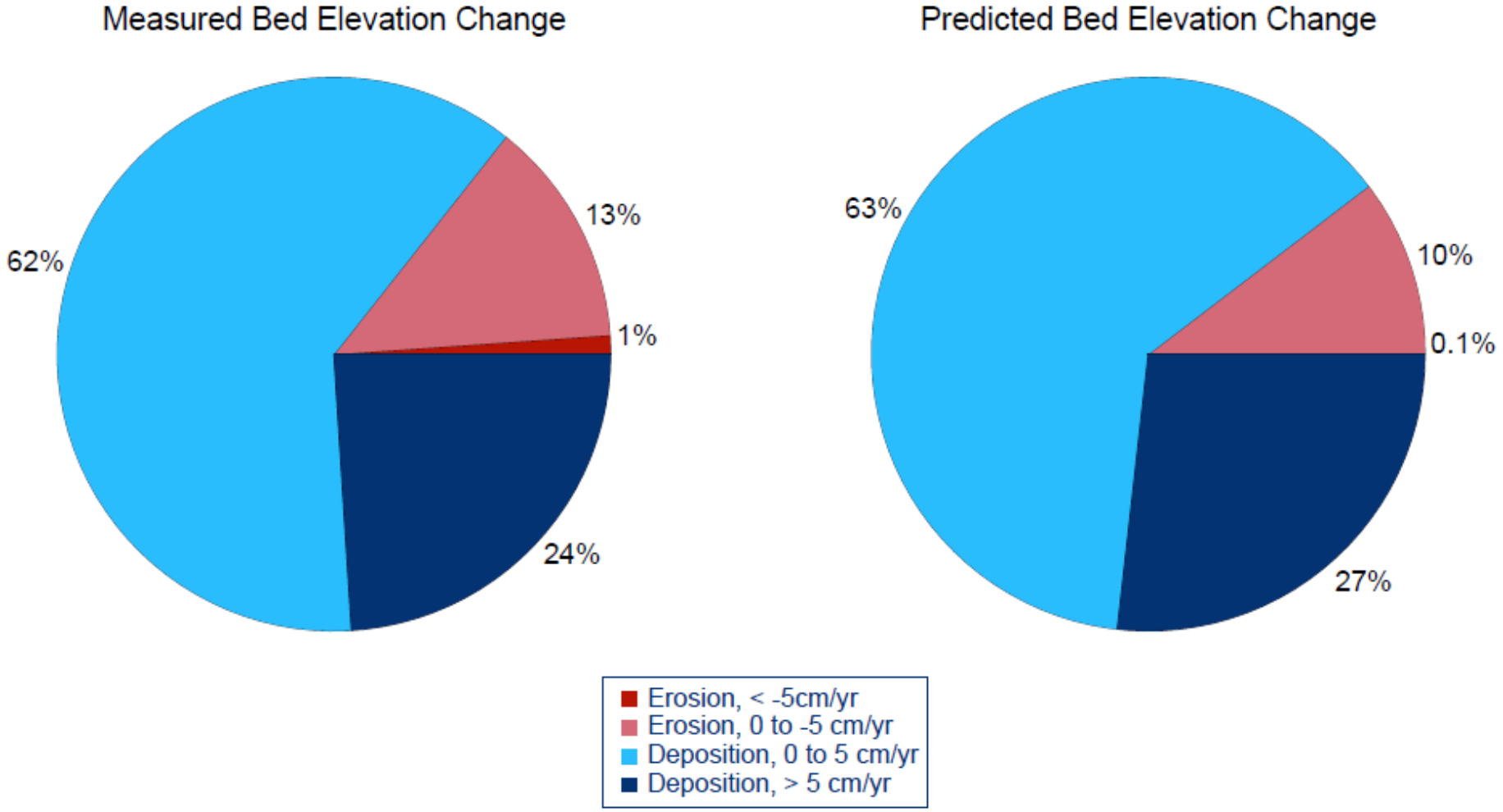
HST Model Calibration: LWR Hydrograph



Overall Mass Balance, RM 2-11: May 2003 – January 2009



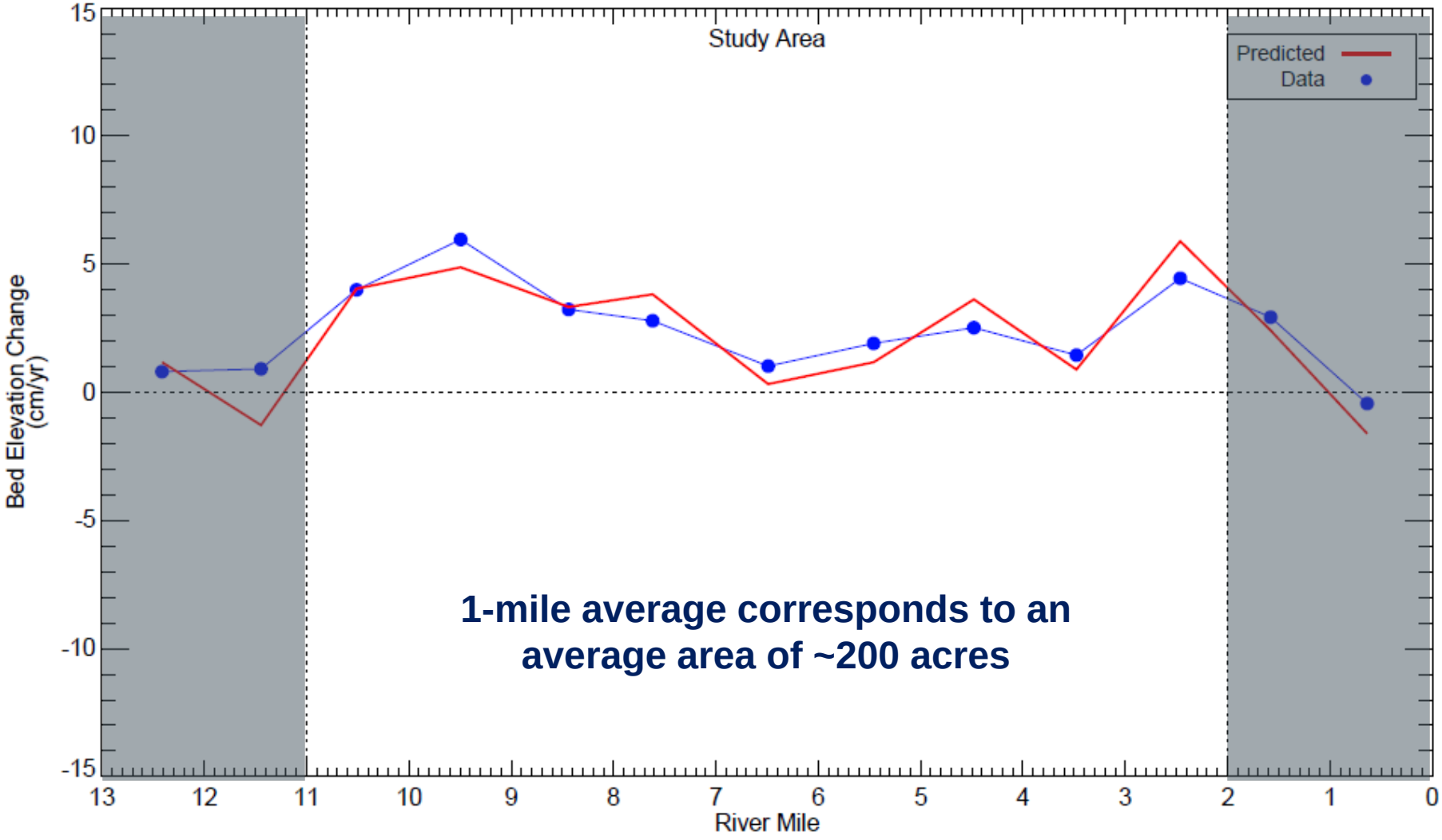
Relative Areal Distribution of Erosion and Deposition, RM 2-11: May 2003 – January 2009



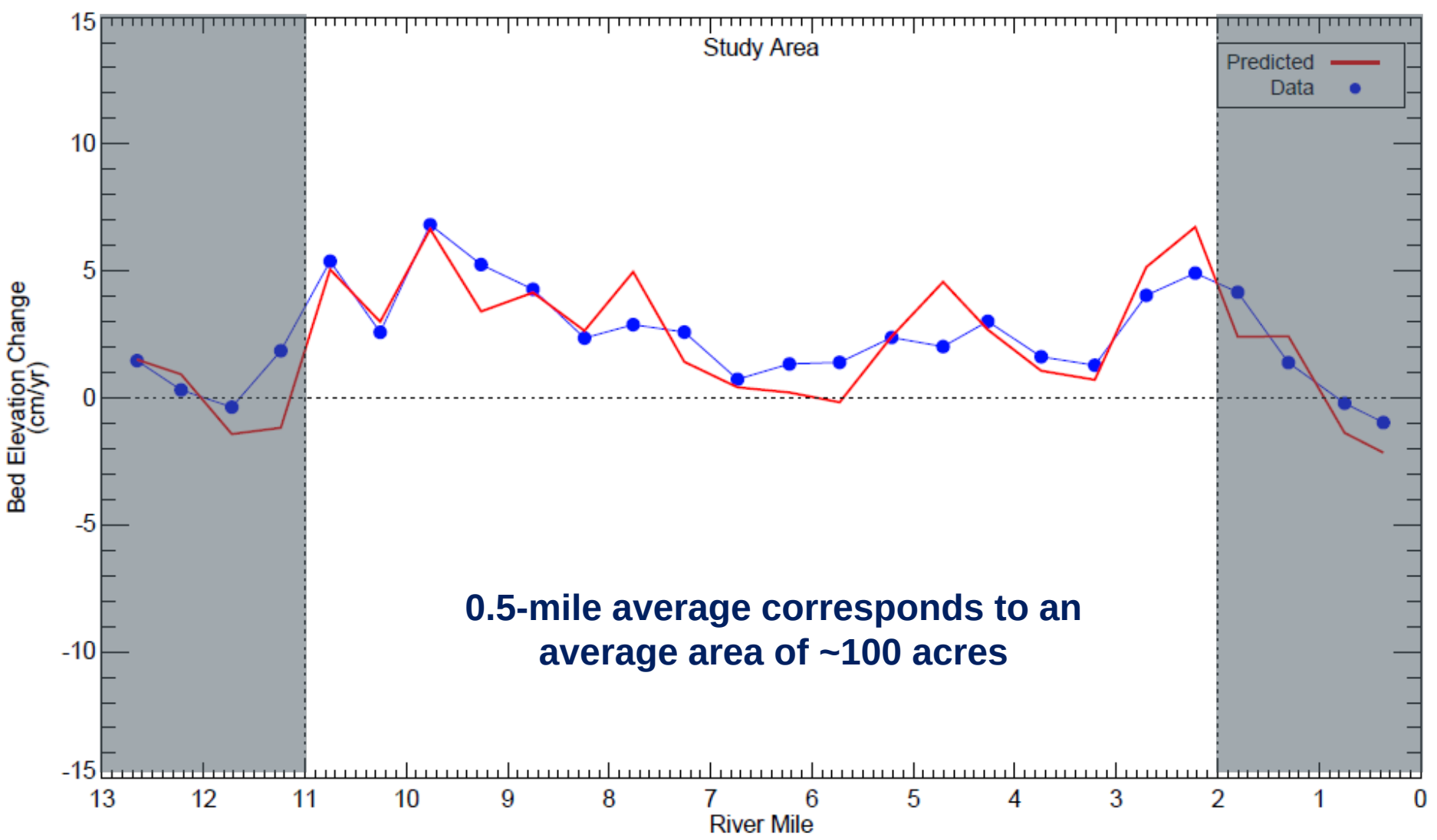
HST Model Calibration Results

- *Spatial scale*: entire study area
  - Net deposition mass and trapping efficiency are accurately predicted
  - Overall spatial distribution of erosion and deposition areas is adequately simulated

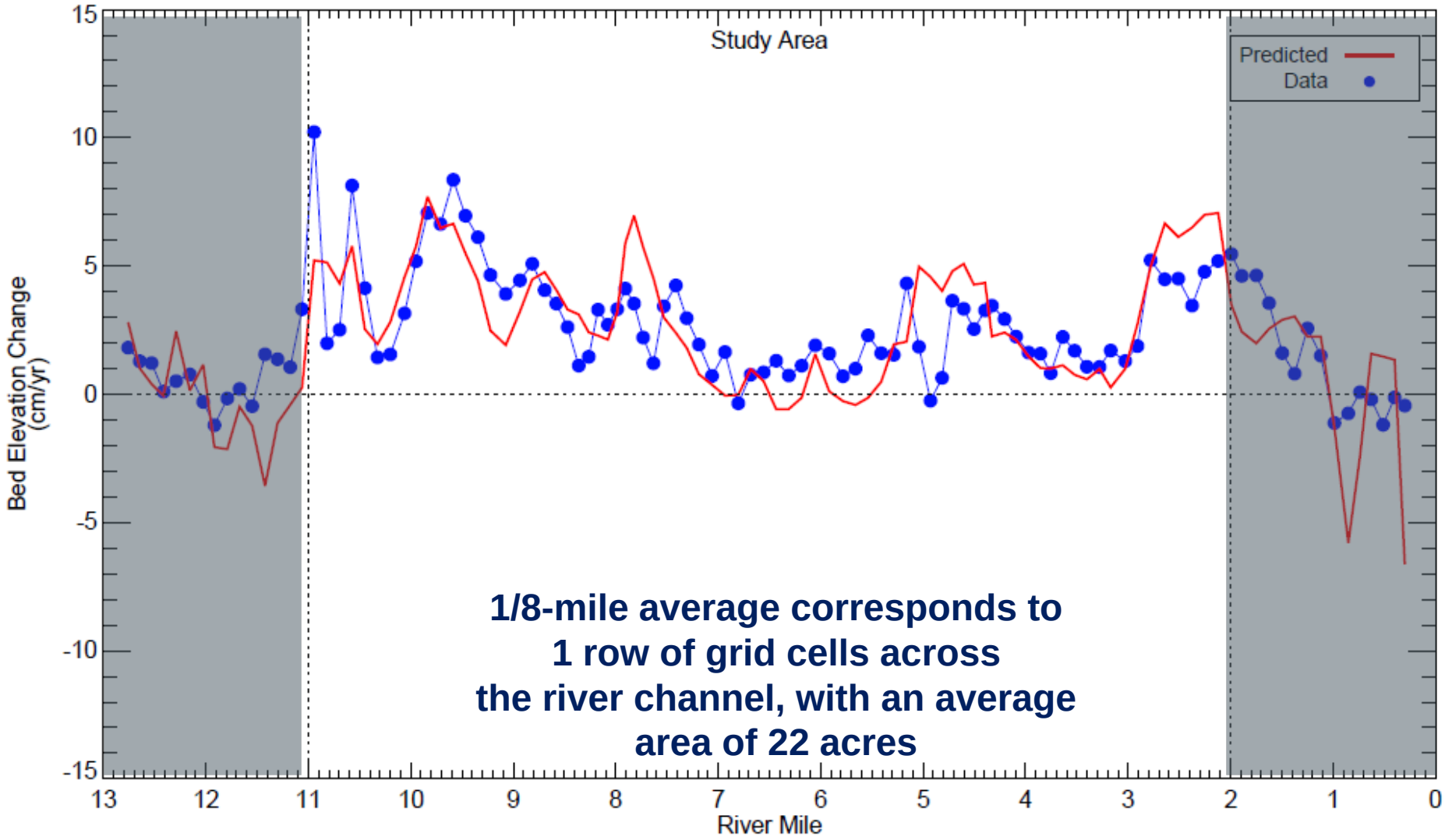
Longitudinal Bed Elevation Change:
1-Mile Average



Longitudinal Bed Elevation Change:
0.5-Mile Average



Longitudinal Bed Elevation Change:
1/8-Mile Average

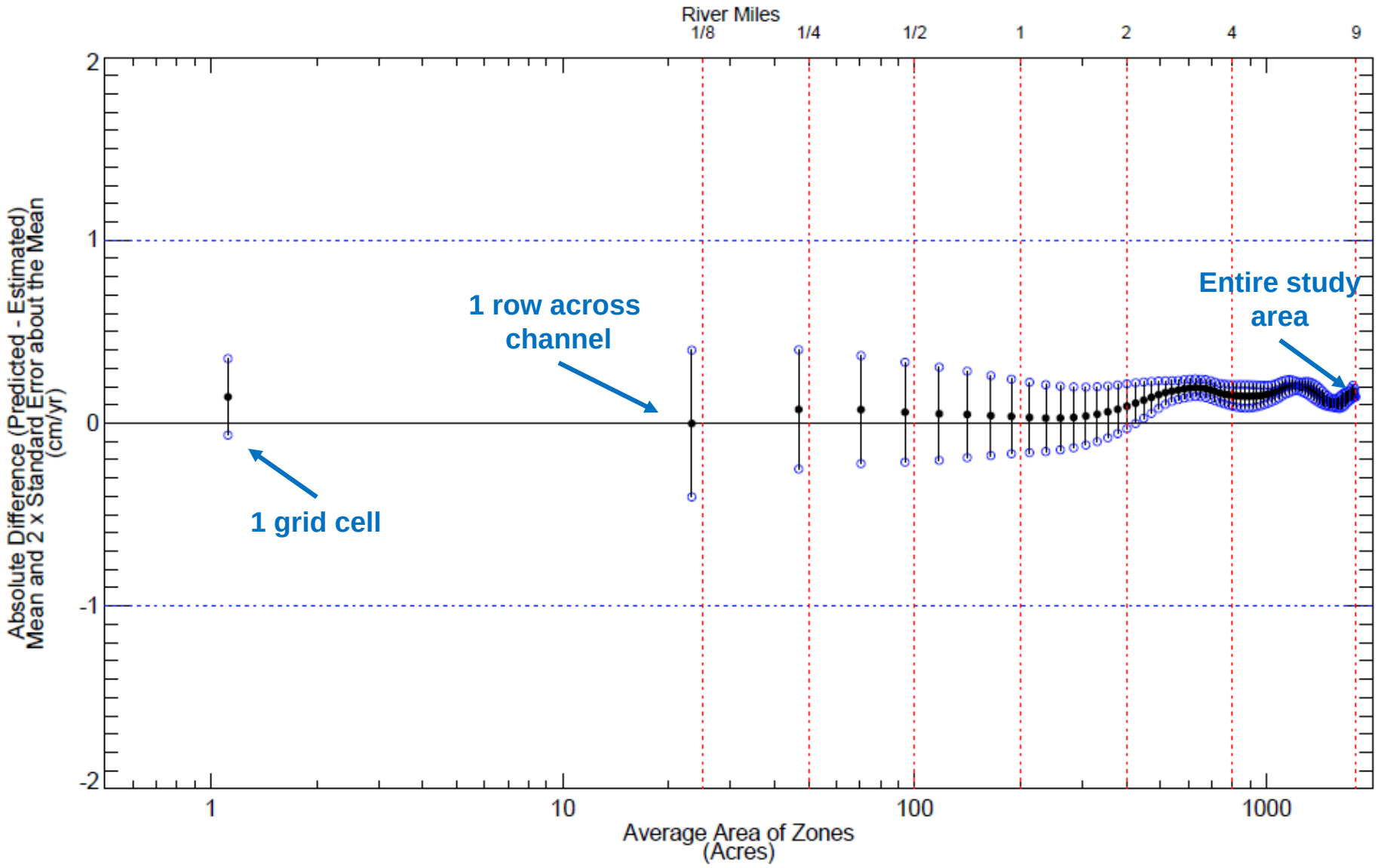


HST Model Calibration Results

- *Spatial scale*: entire study area
  - Net deposition mass and trapping efficiency are accurately predicted
  - Overall spatial distribution of erosion and deposition areas is adequately simulated

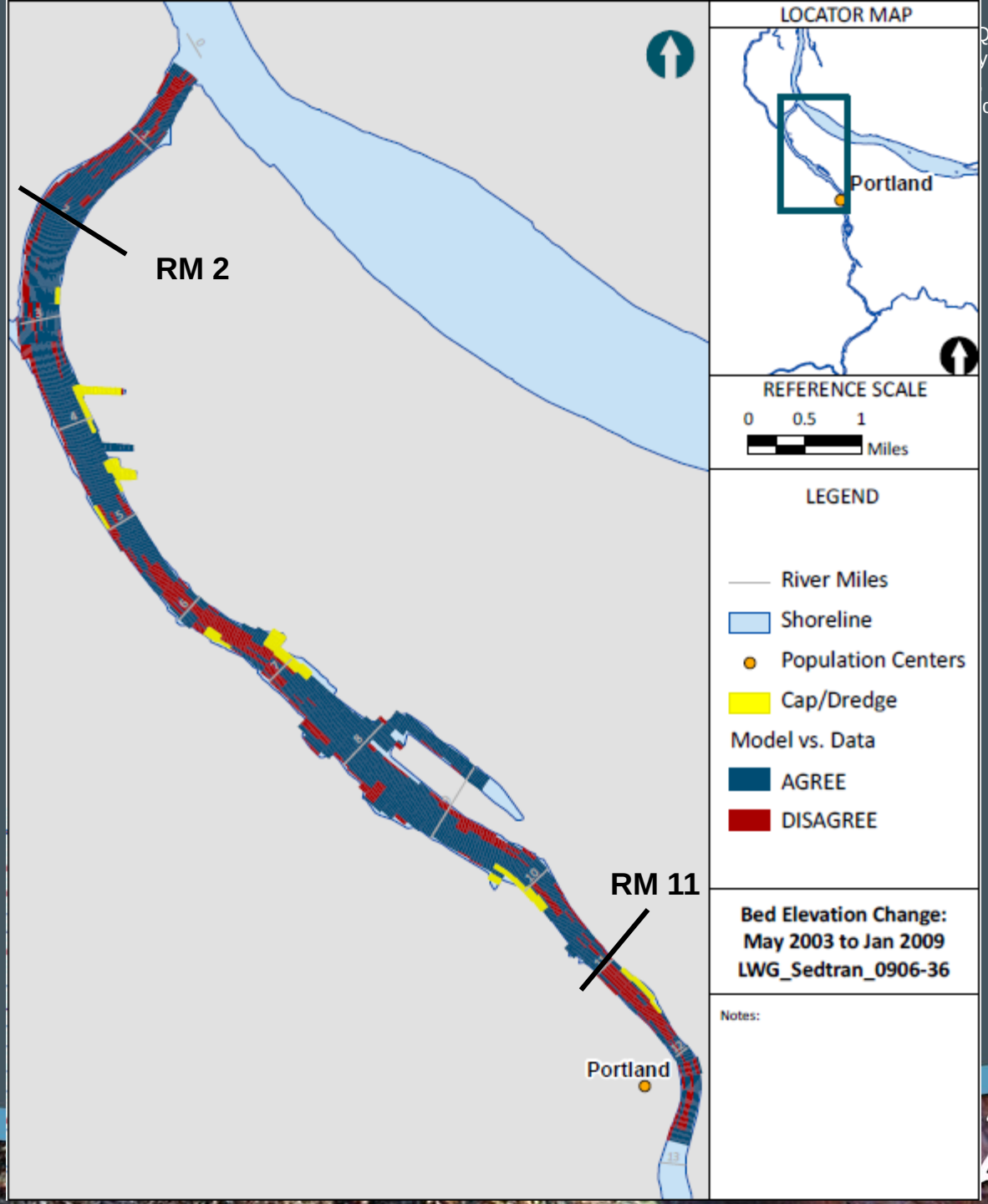
- *Spatial scale*: laterally-averaged, longitudinal distribution
  - Model adequately simulates longitudinal variations in laterally-averaged bed elevation change, from 1-mile to 1/8-mile scales

Spatial-Scale Analysis, RM 2-11:
May 2003 – January 2009



HST Model Calibration Results

- *Spatial scale*: 1-acre to 1,800 acres, average predicted-data difference
  - Model has approximately same predictive capability, on average, over entire range of spatial scales
  - Model tends to over-predict net deposition, but by a relatively small amount (< 0.2 cm/yr)



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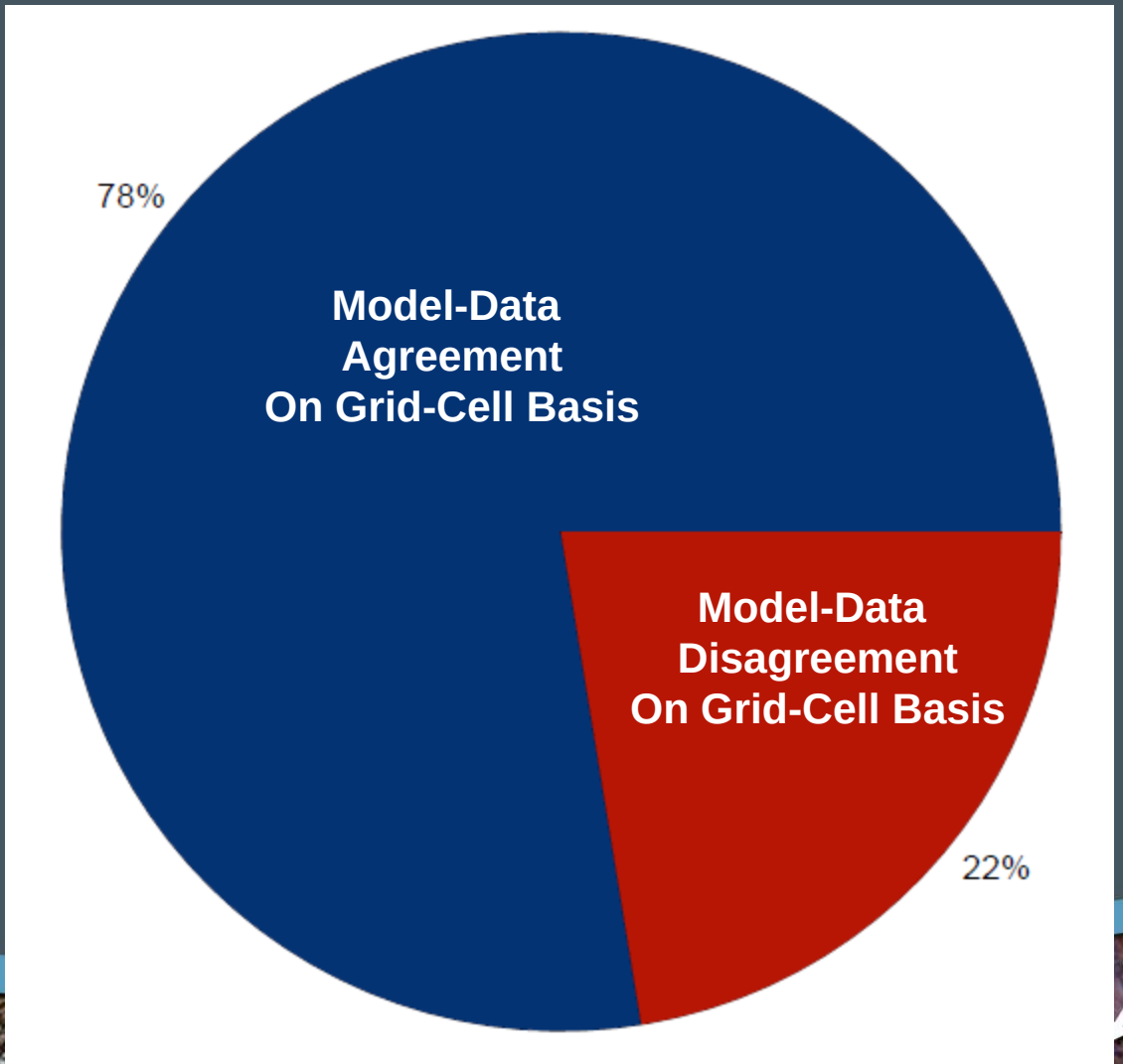
Qualitative Agreement Between Erosion and Deposition Areas, RM 2-11: May 2003 – January 2009



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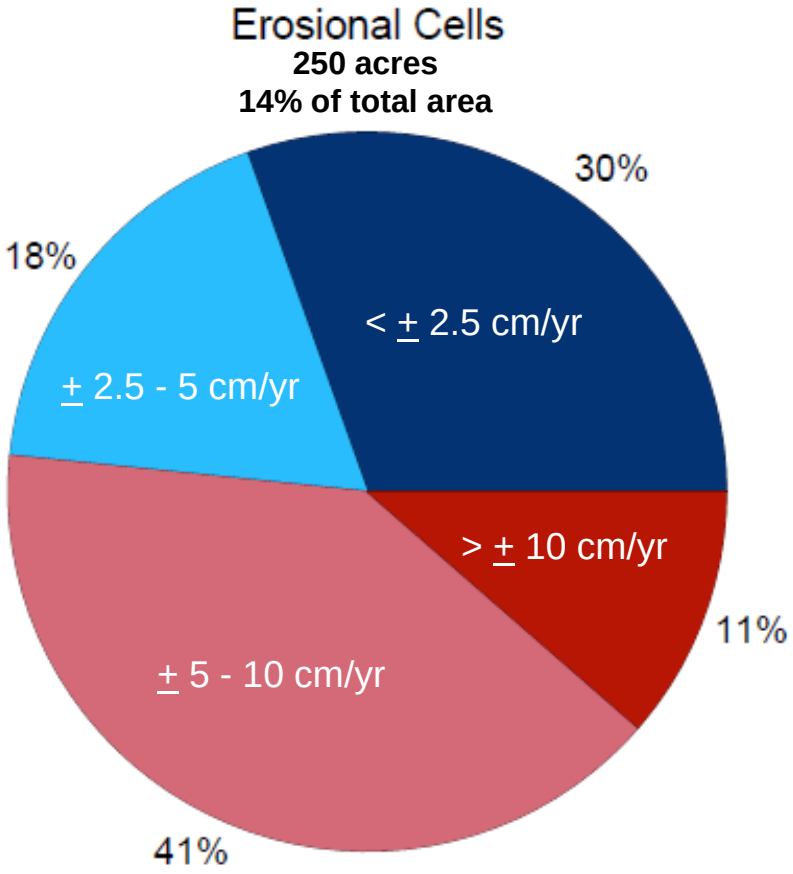
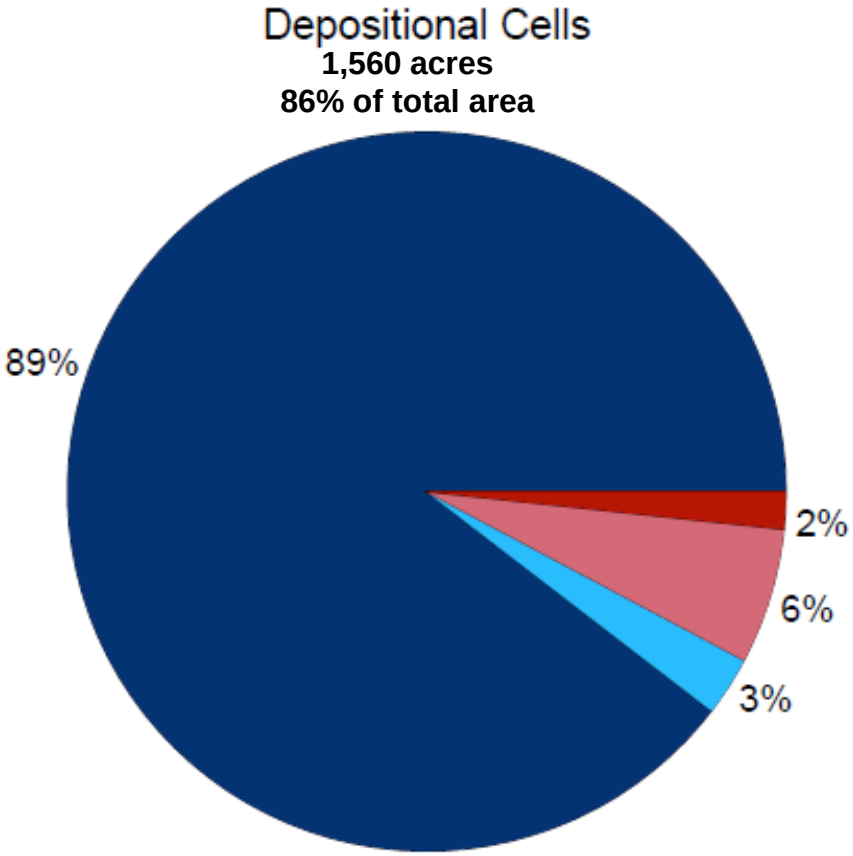
Quantitative Agreement at Grid-Cell Spatial Scale, RM 2-11: May 2003 – January 2009





HST Model Calibration Results

- *Spatial scale*: 1-acre to 1,800 acres, average predicted-data difference
  - Model has approximately same predictive capability, on average, over entire range of spatial scales
  - Model tends to over-predict net deposition, but by a relatively small amount (< 0.2 cm/yr)

- Spatial scale: 1 grid cell (~1 acre)
  - Significant variability exists in the predictive capability of the model at this spatial scale

Summary of HST Model Calibration

- The revised HST model was successfully calibrated
- Within the study area (RM 2-11), the model is able to adequately simulate:
  - Large-scale deposition and erosion processes
  - Longitudinal variations in laterally-averaged bed elevation change
- At grid-cell spatial scales (~1 acre), model predictions have approximately zero bias (on average)
  - Significant variability exists in model predictive capability at this spatial scale